Mrs. R. W. Lesley 6/1/36

CEMENT PIPE AND TILE

ADVANTAGES OF CEMENT FOR PIPE AND TILE, METHODS OF MANUFACTURE, TESTS, COST, ETC.

BY

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PREFACE.

So many inquiries have come to the writer regarding the various problems of cement pipe and tile manufacture that there has seemed to be a demand for a little manual such as the present volume aims to be.

In its compilation many sources of fragmentary published matter have been drawn upon. The writer has, in addition, visited a number of cement tile plants, gathering at first hand the methods and the experience of successful manufacturers. He has also consulted engineering and chemical authorities, and has endeavored in every way to have the book present the latest developments in this rapidly growing branch of the concrete industry.

He realizes, however, that the business is but in its initial stage—that there are many problems to be worked out, many tests to be made, before the manufacture of this product can be considered an exact art. The undersigned will therefore welcome letters from manufacturers of cement pipe and tile in all parts of the country—telling of their methods, their successes, their discoveries—anything which will add to the sum total of knowledge on the subject. These letters will aid in large measure in getting out subsequent editions of the book, making them more valuable to the growing ranks of manufacturers, to whom this present volume is dedicated.

E. S. H.

Chicago, January 4, 1909.

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Cement Pipe and Tile

CHAPTER I.

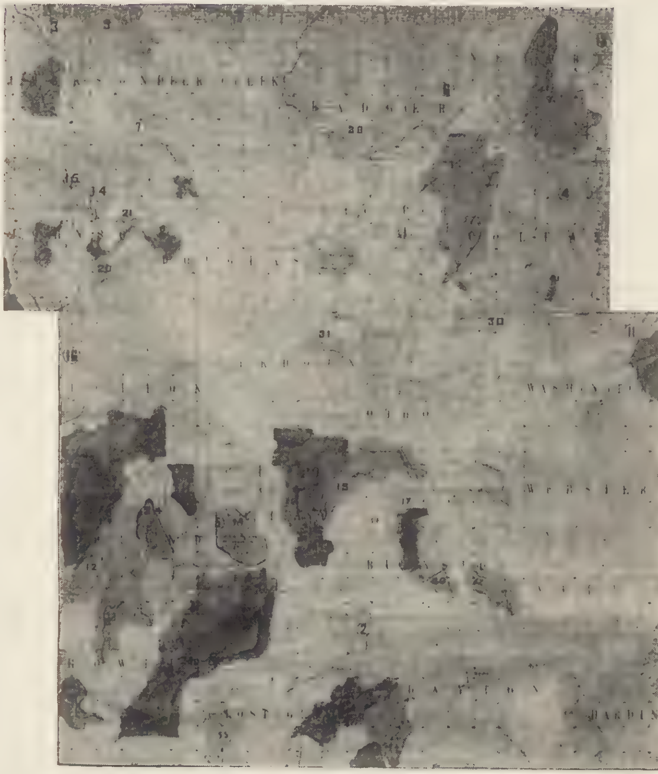
The Growing Demand for Drainage.

The familiar characterization of the intelligent producer is to say that he is the one who makes two blades of grass grow where one grew before. Much more, then, must we say for the man who brings forth a crop of marketable produce with perennial regularity from soil which, before his magic touch, had produced nothing but bulrushes, green scum and malarial vapors.

This is the work being done by those engaged in drainage. It is not a new work, except in the very general manner in which it is being undertaken at the present time. There seems to be a veritable wave of sentiment in favor of drainage sweeping over the country. Where formerly the individual farmer laid a few tile on the worst parts of his land, these emptying into an illy constructed ditch, which in turn emptied into a meadow stream, at the present time public drainage districts are laid out all over the country, organized under the laws of the several states, with power to levy assessments against the property benefited, and employing competent engineers to carry on the work after the most approved practice.

In the early settlement of our country the farms were located on what were considered the most desirable tracts, determined by accessibility, natural water supply, and the fertility of the soil. As civilization extended westward the homeseeker selected the rolling prairie that needed little or no drainage, so that the swamps and overflowed lands were passed by, and only recently has an imperative demand arisen for their reclamation. The desirable farming land is practically all occupied or held for speculation, and to meet the needs of our steadily increasing population it is necessary for this swamp land to be drained and put to proper use.

On November 18, 1908, I was in Algona, Iowa, the county town of Kossuth county. This happened to be the date of the letting of the contract for executing the work of a drainage district in a certain section of the county, and on consultation with the



MAP OF WEBSTER COUNTY, IOWA, SHOWING IT ALMOST COMPLETELY COVERED WITH DRAINAGE DISTRICTS.

county auditor I found that this one piece of work required the following amounts of tile:

6,600 feet of tile 18 inches in diameter
1,700 feet of tile 14 inches in diameter
300 feet of tile 12 inches in diameter
2,800 feet of tile 10 inches in diameter
2,100 feet of tile 9 inches in diameter
500 feet of tile 7 inches in diameter
2,350 feet of tile 6 inches in diameter
400 feet of tile 5 inches in diameter

This is a total of nearly 17,000 feet of tile on one district—and this district is No. 34! This goes to show something of the

extent of the drainage proposition. This county has on hand at the present time work amounting to nearly $500,000, with 120 miles of tile mains, and in addition to that is an immense amount of farm drainage done by the farmers themselves.

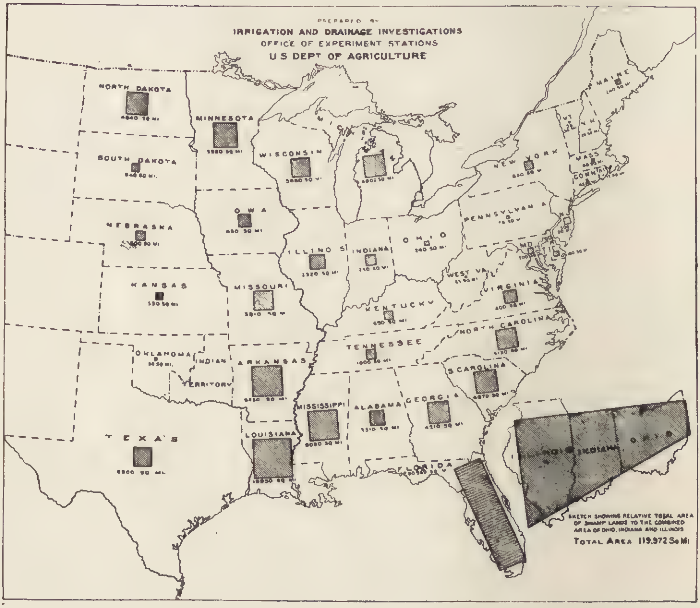
Another glimpse can be had at the extent of this class of work by a glance at the accompanying map of Webster county, Iowa, in which the drainage districts are shown. Here the county work runs up to over $600,000.

This is merely two counties of one state. Other counties and other states are working along the same lines, following the strong public trend toward fitting for productiveness every acre of our broad domain.

Not all swamp land is suited for tillage, but from the data collected and analyzed by the Department of Agriculture it is certain that there are in the United States east of the Rocky Mountains 77,000,000 acres that can be reclaimed and made fit for cultivation by the employment of simple means. This estimate is given on the authority of Mr. J. O. Wright, supervising drainage engineer in charge of drainage investigations for the Department of Agriculture, who says that this land is distributed throughout the several states as shown on the map on the following page.

Because these lands are found in widely separated tracts their vast extent is not fully realized. Were it possible to collect them into one body it would make an empire as large as England, Ireland, Scotland and Wales. If placed in the eastern part of our own country it would cover the six New England states, New York and the northern half of New Jersey. It would make a strip 133 miles wide reaching from New York to Chicago.

There is no question as to the fertility of swamps or overflowed land, and when it is protected by embankments to keep out the overflow and is relieved of the excess of water by proper drainage its productiveness is unexcelled. In nearly every one of the states large areas of similar lands have been reclaimed by draining and embanking and have proven to be the most productive farm lands in the districts in which they are located. Illinois, Indiana, Iowa and Southern Louisiana have taken the lead in work of this kind, and in no other part of the country do we find more profitable or higher-priced farms than in those states. Along the Atlantic coast sufficient work has been done to indicate that the vast extent of salt marsh reaching from Maine to Florida can by proper methods be won to agriculture, and when reclaimed the soils are especially adapted to market gardening. Their fer-



MAP SHOWING THE AREA OF SWAMP AND OVERFLOWED LANDS IN THE STATES EAST OF THE ROCKY MOUNTAINS.

tility has been fully established by chemical analysis of the soil and by hundreds of productive farms that have been made from such lands.

As to the cost of draining these lands, and whether or not it will pay (quoting Mr. Wright), we have but to refer to the numerous works of this kind that have been completed. In those states where large areas of swamp land have been thoroughly drained by open ditches and tile drains the cost ranges from $6 to $20 per acre, while in places where tile drainage was not required the average cost has not exceeded $4 per acre. Judging from the prices which prevail in a large number of these districts where work of this kind is being carried on, it is safe to estimate that the 77,000,000 acres of swamp can be thoroughly drained and made fit for cultivation at an average cost of $15 per acre. The market value of these lands in their present shape ranges from $2 to $20 per acre, depending upon the location and prospect of

immediate drainage, with an average of probably $8 per acre. Similar lands in different sections of the country that have been drained sell readily for $60 to $100 per acre at the completion of the work, and in many instances, when situated near large cities, they have sold as high as $400 per acre. To determine whether or not it will pay to drain these lands we have but to consider the following figures:

Cash value of 77,000,000 acres after thorough drainage at $60 per acre		$4,620,000,000
Present value of the land at $8 per acre	$ 616,000,000	
Cost of drainage at $15 per acre	1,155,000,000	
Value of land and cost of draining		1,771,000,000
New increase in value		$2,849,000,000

These figures, though large, are not fanciful, but are based on results obtained in actual practice in different sections of the country where work of this kind has been done. An extended investigation shows that in every case where a complete system of drainage has been planned and carried out the land has increased in value many fold. In some instances, however, much time and money has been wasted because the work was undertaken without any well defined plan, or it was not sufficient to afford adequate and complete drainage.

Were this 77,000,000 acres of swamp and overflowed land drained and made healthful and fit for agriculture and divided into farms of 40 acres each it would provide homes for 1,925,000 families. Swamp lands, when drained, are extremely fertile, requiring but little commercial fertilizer, and yield abundant crops. They are adapted to the growth of a wide range of products, and in most instances are convenient to good markets. While an income of $15 to $20 per acre in the grain-producing states of the Middle West is considered profitable, much of the swamp lands in the East and South would, if cultivated in cabbage, onions, celery, tomatoes and other vegetables, yield a net income of more than $100 per acre.

In addition to the immediate benefits that accrue from the increased productiveness of these lands, a greater and more lasting benefit would follow their reclamation. The taxable value of the commonwealth would be permanently increased, the healthfulness of the community would be improved, mosquitoes and malaria would be banished and the construction of good roads made possible. Factories, churches and schools would open up, and, in-

stead of active young farmers from the Mississippi Valley emigrating to Canada to seek cheap lands they could find better homes within our own borders.

Holland, two-fifths of which lies below the level of the sea, has been reclaimed by diking and draining, and now supports a population of 450 per square mile. Her soil is no better than the marshes of this country and her climate not so good as that of the Southern States, yet we have within our border an undeveloped empire ten times her area.

The removal of the excess of water from the soil, either by ditches or by tiles, is one of the first principles of good husbandry, and one which has been neglected so much in the farming districts of this country. When soil is drenched with water and dries by evaporation it becomes hard; land that is dried by drainage is porous and permeable to the dew and showers; while the soil deepened by drainage permits growing crops to put forth longer roots, and thus become secured against drouth.

Experiments in draining sloughs have shown that when the water is given free passage through a cold soil by thorough drainage its temperature at eight inches may be raised ten degrees above that of the adjoining undrained soil.

Draining land by means of tile is far more effective than by means of open ditches.

Low land drained can be cultivated earlier in the spring than high land not tiled.

Experiments have shown that the increased warmth is a great factor in promoting the germination of the seed and the advanced growth of the crops. It also promotes pulverization of the soil, removes stagnant water, gives a free circulation of air to its pores, which is essential to the proper growth of the plant life, and fits the land for the life and action of the soil bacteria, increasing the growth of alfalfa and other clovers, which will not grow where the soil is soaked with an excess of moisture.

Drainage enables the roots of plants to penetrate deeper into the soil, where they are protected from the heat and drouth, enabling the plants to better stand dry periods.

The greatest trouble with the selling of tile to the farmer is to convince him that it is a benefit to the land to use a larger tile than he generally orders, just for the sake of saving a few dollars in the first cost. Thousands of acres of land are now being drained with a too small tile, which in a short time will have to be taken up and relaid with a larger size, the user in nine times out of ten,

because the tile was not carrying the water off the land, condemning the system of drainage.

The farmers of Illinois have gone through the experience of using too small a drainage tile, causing the loss on each quarter section of hundreds of dollars. The buyer should be advised to get a competent engineer to survey his land and get the necessary size of tile to do effective work in carrying off the surplus water.

The advantages of tile drains are summarized by Prof. A. Marston, dean of the Iowa College of Engineering, as follows:*

1. Tile drainage, by making the soil firm, enables earlier cultivation in the spring. Low ground drained can be cultivated earlier than high ground not drained.

2. Careful observations have shown that the tile drainage makes the soil several degrees warmer in the spring. Scientific tests have shown this increased warmth to be of the utmost importance in promoting the germination and growth of crops.

3. Tile drainage promotes pulverization of the soil, putting it in good condition to cultivate, and preventing baking and the formation of clods.

4. Tile drainage removes from the pores of the soil surplus and stagnant water, which would drown and destroy the roots of plants.

5. Tile drainage makes certain the proper "breathing" of the soil, or free circulation of air in its pores, which is essential to healthy plant growth.

6. Tile drainage establishes in the soil the proper conditions required for the satisfactory carrying on of the chemical processes necessary to prepare the plant food for its use by vegetation.

7. Tile drainage fits the soil for the vigorous life and action of the soil bacteria which are essential to preserve and increase its fertility and promote the growth of crops.

8. Tile drainage increases the depth of soil which can be reached by the roots of plants and drawn upon for plant food.

9. Because in them the roots of plants can penetrate deeper, where they are protected from the heat and drouth and can reach the deep-seated moisture, tile-drained soils stand drouth better than undrained soils.

10. By putting the top 3-foot or 4-foot layer of soil into a porous condition, tile drainage enables soils to absorb rain water instead of discharging it over the surface, and so helps to prevent surface water wash and consequent loss of fertility.

11. By causing this porous condition, tile drainage makes the upper 3 or 4 feet of soil into an enormous reservoir to catch the rain water and discharge it only slowly into the streams. Thus tile drainage prevents floods instead of causing them.

12. Tile drainage does away with irregular shaped fields, cut up by sloughs and ditches, and so cheapens cultivation.

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*"Sewers and Drains," by A. Marston; published by American School of Correspondence, Chicago.

CHAPTER II.

Advantages of Cement for Pipe and Tile.

It should afford much gratification to the thrifty land owner to place under his fields a tile which will improve in durability as the years go by. This is in reality what he is doing when he uses cement tile.

That concrete in its initial stages improves with age is a fact well recognized even by the most casual observer. A few hours after it has been molded, it has set so hard that its form and shape cannot be changed. No one claims, however, that at this point the tile is ready for use. The process of crystallization has but just commenced. This process is carried on under certain favorable conditions for a few days and the product is then allowed to lie for a number of more days to attain strength. The thirty or forty days after which tile is removed from the yard is, however, simply an arbitrary limit set, below which the tile must not be used. This does not mean that the process of growth going on in the tile has ceased. This process, as is well known to close students of the subject, goes on almost indefinitely, and as it progresses, the more compact and strong does the mass become.

If one goes into the laboratory at a cement plant, he will find stored away on shelves, briquettes of cement immersed in water or under other conditions, which are being kept for a term of years in order that the long process of crystallization may be carefully studied. Tests made upon these will show an increase of strength from year to year.

It is not, therefore, too much to say that one of the greatest advantages of cement tile is the fact that it increases in strength with the lapse of time. From the very nature of the case, it is kept almost constantly moist, the necessary amount of water for crystallization thus being supplied.

With clay products, on the other hand, it is a well known fact that they are at their best when they first come from the kiln. In the process of burning, the curing of the tile has been completed for all time. It comes from the kiln a lifeless thing, ready to be attacked by outside conditions the moment it reaches the storage

yard. If the burning in the kiln has been imperfect, the tile must remain imperfectly cured. Cement tile, however, even though it may have been improperly made and cured in the first place, has the power of life within itself, so that even after it is laid, the process of acquiring strength and durability will be carried on.

The uniformity of shape of cement tile is one of their strong recommendations. They come from the molds perfectly round, true on the ends, and without imperfections in shape of any kind. This advantage of cement tile is most frequently spoken of by men who lay them, and their preference is always for this class of tile. Clay tile, in the process of handling in the yards, handling in the kilns, burning, etc., are apt to get very much out of shape. They lose their true round section, are apt to be bent from the straight line, and the ends are very often imperfect. On this account, the tilers have to take particular care in laying them, often turning them over several times to make them fit one to another. Each cement tile, however, is a perfect cylinder. The same fact has also been noted by ditchers who use a mechanical ditcher which lays the tile automatically. Cement tile go through the machine with little or no trouble, while clay tile have to be watched, and at best are very apt to clog the machine.

Another advantage of cement tile is that they can be manufactured at a large number of different points, thus eliminating to a very large degree the item of transportation. A cement tile plant requires comparatively little equipment, and such equipment as is required is standard, readily secured and easily operated. The larger part of the work can be done by such common labor as can be found in any community. The only raw material which has to be secured locally is a supply of sand and gravel, which can be found almost anywhere. True, the cement must be shipped in; but it goes at a very low rate, constitutes only a fraction of the total weight of the product, and is not subject to breakage or other loss.

In contrast to this, let us look at the conditions under which clay tile are manufactured. In the first place, a suitable supply of raw material must be found; and clay suitable for this purpose is not obtainable everywhere. Then, there must be specially designed buildings and an equipment of expensive machinery and the employment of skilled help. This means an outlay of anywhere from $30,000 up. It also means a large running expense for fuel to keep the kilns burning. All these facts mean that clay tile plants must of necessity be at a considerable distance apart and must

work under the disadvantage of making long shipments by rail. The county, however, which does considerable tile work, could support one to three cement tile plants, and could thus secure tile without any rail shipments whatever.

In a large number of cases, due to some of the facts already mentioned, cement tile can be sold at a lower figure than clay tile. While the prices in most localities run along fairly uniform, any difference there may be is always in favor of the cement product.

Another advantage is that a cement product of this character is very largely under control of the manufacturer. He can regulate the permeability of the tile to suit the conditions or the desire of the customer. While it is undoubtedly true that cement tile become more impervious with age, they will in most cases, under the ordinary process of manufacture, carry more water through their walls than clay tile, thus facilitating the drainage of the land.

Cement tile can be submitted to the action of frost with more safety than clay tile. This does not mean that they should be left in the water indefinitely to thaw and freeze, but it does mean that they can be distributed over the ground in winter when it would not be safe to lay out clay tile.

Mr. F. A. B. Patterson of Fairmont, Minn., has made experiments which showed cement tile to be superior to clay in withstanding freezing. A 6-inch concrete tile and a 6-inch clay tile were placed in a V-shaped trough and water poured in so that the tile was more than half filled with water; the trough and tile were then placed outside and allowed to freeze solid, remaining so for two days. They were then thawed out and, upon examination, the concrete tile was found intact, whereas the clay tile was split from end to end in three places. Again, clay and concrete tile was placed in the ground and filled half full with a very thin mud, covered over to the depth of a foot of earth, and allowed to freeze; in the spring when it thawed out, the tile were examined and the same result as in the first experiment was shown.

Mr. Hering's Arguments.

Mr. Rudolph Hering. the New York engineer, gives the following five arguments in favor of concrete for sewer pipe, in *The Concrete Review* for March 15, 1907:

I. A sectional form can be given them which is more conducive to stability and efficiency than round clay pipes.

(*a*) While for purposes of even burning a nearly uniform

thickness is desired for clay pipe, no such requirement is necessary for molded concrete pipe, which, when setting, retains its shape and grain. It is therefore possible to give concrete pipes better sectional forms, as referred to under (*b*) and (*c*).

(*b*) It is practicable and customary in Europe and in America to give concrete sewers a flat, broad and level base. Such a base has the advantage of allowing the pipe to rest firmly and securely upon a continuous flat earth foundation, as compared with the circular bed required for circular pipes, with the necessity of cutting out a depression in which the bells can rest. The difficulties of securing a perfect bearing for the barrel of circular pipes by tamping the earth backfilling into the space beneath the two sides of the pipe are not slight, and often have been the cause of a breakage of the pipe on account of an insufficiently strong bearing due to hollows left by insufficient compression of the material. In fact, to get in this respect the same advantages as flat bottom cement pipe it is customary in some places to put a layer of concrete into the trench, upon which subsequently the vitrified pipe is laid, the concrete being then brought up to the spring of the pipe.

(*c*) The oval or "egg" shape for such sewers as have a variable flow has great advantages over a circular section, which is well known. It has not been found practicable to give the vitrified pipes a true oval section on account of the warping due to burning, and therefore only a circular shape is now generally in use. While this shape is sufficiently good for small pipe sewers less than 12 inches in diameter, it is often not as good as the egg shape for sewers over 12 inches in diameter. Cement and concrete sewers can as readily be made egg shaped as circular.

II. As vitrified pipe warps in burning the section is not finished truly circular, and slight projections are formed at every joint when the pipes are laid to form a sewer. These projections are more or less objectionable in a sewer, because suspended matter catches and is retained thereby. Cement and concrete pipes, whether circular or egg shaped, do not warp, and therefore can give a sewer an even surface upon which the sewage can flow.

III. As cement pipes have a truer sectional shape than vitrified pipes, they can be given a slanting butt joint, as is customary in Europe, instead of the more costly bell and spigot joint common for vitrified pipe, which are made in imitation of cast-iron pipe used under high pressures. Vitrified and cement pipes are never used under high pressures, and the hub and spigot joint, as now used, seems to be of advantage only to obviate the difficulties

of joining two pipes which are not exactly true in section. The slanting butt joint is therefore quite rational for concrete pipes, while this is not so for vitrified pipes. It is less expensive to make, both in manufacturing the pipe and in joining the pipes with mortar in the trench.

IV. Concrete pipes are tougher, that is, less brittle, than vitrified pipes. Therefore, they are not as easily broken by rough handling and by having heavy matters drop upon them.

V. Concrete pipes, if well made of proper materials, have a strength to resist compressive, tensile and bursting strains which is amply sufficient for all purposes of a sewer in a large city.

In the same issue of the publication above quoted Mr. Robert W. Lesley, of Philadelphia, says:

There seems to be no question whatever that in form, especially the oval, cement pipes are far superior to the ordinary clay pipes; that in cost, requiring, as they do, no cradling, they are infinitely preferable upon the ground of economy.

As to acid, certainly sewage contains no more acid than the water used in the manufacture of paper. There sulphuric acid is used in sufficient quantities to digest wood to paper pulp.

Various illustrations are given upon this subject, namely: the Willcox Paper Mills at Glen Mills; the use of concrete for lining the digestors in paper mills at Holyoke, Mass.; in fact, all through the United States, and the use of concrete for the floors in the paper mills at Long Island City.

Certainly in no case of sewage is there a deliberate intent to get the acids which would attack cement in such concentrated form as they are found in the manufacture of paper, where the acids, hydrochloric and sulphuric, are actually used to destroy the wood pulp in the preparation of the finished product.

Mr. J. P. Sherer, of the Board of Public Works, Milwaukee, in an address before the Northwestern Cement Products Association, held in Chicago, in December, 1907, made the following remarks, bearing on the subject of concrete pipe:

Few people realize the extent to which concrete sewer pipe is used. Out of 300 miles of sewerage in Milwaukee, as near as I can learn, over 200 miles is made of concrete, which speaks well for a product of that kind. In all places where we had to replace the sewers that were put in in the early history of Milwaukee, we found the concrete pipe to be intact. For instance, only recently, we were required to take up 12-inch pipe and replace it with 20-inch, and for the entire length that pipe was found to be in elegant condition—very much harder than when first placed there. There was no defect or flaw from one end to the other, and there was fourteen or fifteen hundred feet on that line of pipe.

Our engineers (of the Board of Public Works) recommend concrete pipe to be the best for the conveying of sewerage that is to be had. We have used various kinds of aggregates for

making this pipe; at times crushed stone and sand; and sometimes gravel and sand. We generally use the ordinary bank gravel, which is the cheapest we can get, and find it sufficient for making the pipe. The pipe is rammed or tamped. Three years ago we put in an air tamper. Before that time we used hand tamping entirely.

Ts and Ys and connections are put on the pipe after it is cured. We make a hole for the connection, place the junction on the inside and cement it up. In joining the pipe we cleanse the broken edges, and get good results. It is a good idea after thoroughly tamping both ends, where you wish to make the union, to make a solution of neat cement, about the consistency of cream, and apply it to both sides. Simply wipe the joints with this solution, as the plumber wipes the joints of lead pipe with molten lead. It never cracks at that point and we have had no trouble whatever. We put junctions on our pipe sometimes 12 to 18 inches in size.

In response to the question, "How do you connect with a sewer not already connected?" Mr. Sherer made the following reply:

"We do that by making holes in the pipe in the manner I have before described. Of course we do not like to have that done in a general way. It is done under the supervision of the Board. If a plumber asks to make a connection for a building, we have an inspector there with the plumber, and he breaks in a hole and makes the connection as I have described. If it is at a place where there is already a connection and it is to be made larger, they simply make a larger hole and cement it up. We put in a large number of house drains of this cement pipe. It is one of the laws of our city that the property is assessed for these connections and we put them in for every lot, but sometimes they are not large enough and we take them out again. These connections can be very readily made by breaking through, as I told you. The work needs to be carefully done, so that the pipe is not destroyed. At times when we have to make a very large connection, we take out one section and insert another one.

Mr. Sherer said further: "The greatest enemy of cement pipe is the vitreous pipe manufacturer. Years ago, in Milwaukee, we were hardly allowed to live. We had a big fight on our hands and we won out, and today if there is any preference shown it is for cement pipe. It is sold there on the same list price as vitrified."

Further statements are made by Mr. George E. Zimmerman, a sewer contractor of Milwaukee, and Mr. Chas. J. Poetsch, city engineer and president of the Board of Public Works of that city. Mr. Zimmerman said:

As the question is being asked about merits of cement sewer pipe, I wish to say that I have relaid 400 feet of 18-inch cement pipe in Poplar street. These pipe were laid about twenty-five years ago. The location was low land and the sewer had settled about 1½ foot, which made it necessary to relay the pipe. I found the

old pipe in perfect condition, and relaid all but five pieces, which were replaced by new pipe. I left these five pipe on the street about thirty days until they were dried out, and then I moved them to a sewer on the south side of city and relaid them, the pipes being better or harder than the new.

The statement by Mr. Poetsch is as follows:

I wish to state that the city of Milwaukee has used concrete sewer pipe for more than thirty years with entire success, and now has nearly 200 miles of such sewers in use. We are building large size sewers of concrete now and find that they can be constructed cheaper and answer the purpose much better than brick sewers.

In Baldwin Latham's work on Sanitary Engineering (published in England in about 1873), the statement is made that Portland cement pipes were made in England probably as early as 1825, before the period when earthenware sewer pipes were beginning to be manufactured, and that he had seen cement pipes that had been used for thirty-five years and they were as sound at the end of that period as when first laid.

Cement pipes of large size, with socket joints, are now extensively used in Germany, and they withstand not only the effects of a severe climate, but the chemical action of sewage. Moreover, they show an extraordinary endurance and remain perfect after a severe frost, when brickwork often fails. It is a material that can be worked and molded in any form and maintains its form when made. It is also capable of repair, which is a point of no small importance. These pipes improve materially by age, and at the end of a year or two they ring when struck with a clear metallic sound.

The modern sewers of Paris are constructed of concrete. As early as 1869 thirty miles of concrete branch and main sewers had been laid in that city, and today throughout Europe both pipe and large sewers are, to a great extent, made of this material.

In America the use of concrete sewers is now beginning to assume magnitude. Since engineers have become more conversant with the properties of concrete their hesitancy in establishing concrete sewers is rapidly disappearing.

Up to 1895 some three hundred miles of cement pipe was laid in Brooklyn. In addition to this many miles was laid in Flatbush, Coney Island, Sheepshead Bay and Bay Ridge before they became a part of the city. These sewers, some of them having been in use nearly fifty years, were laid during the administrations of James C. Kirkwood, Col. Julius W. Adams, Moses Lane and Robert Van Buren, chief engineers of city works, who advocated

their use for reasons of their serviceability and cost. The pipe made at the present time, needless to say, is much superior to the early made pipe, not only on account of the introduction of machinery, but on account of the improved Portland cement now invariably used.

Brooklyn manufacturers at first made a round pipe of Rosendale cement and these were found to give very satisfactory results, but in a short time egg-shape flat base bottom pipes were introduced and proved so superior that they were adopted for the pipe sewers of Brooklyn. The large bulk of these sewers are still in service and are in as good condition as when first laid. As a proof of this statement may be cited an instance where the Fleet street, Brooklyn, sewer was uncovered while excavating in the early part of 1906 for the Rapid Transit subway on Fulton street, Brooklyn. Concrete pipe sewers and vitrified pipe sewers of Scotch make, were both exposed, and in all cases the concrete pipes were intact, while the vitrified pipes were invariably cracked or broken. The sewer was laid over forty-five years ago.

In 1895 a number of unscrupulous manufacturers entered the business, who, by their actions, brought the concrete pipe industry into disrepute. Miles of so-called cement pipe, with practically no cement, was laid which soon crumbled and had all to be replaced. This led to the stoppage of the use of cement pipe entirely in the city for a period of three or four years.

Concrete pipe was again, however, permitted to be used since 1904 under specifications which prescribe the cement to be used, the mix and other details of manufacture. Since that time many miles of cement pipe have been laid in Brooklyn.

Of the many hundred miles of concrete pipe furnished by the Wilson & Baillie Manufacturing Company and laid in Brooklyn there has been no authenticated report of breakage or failure. Of the many instances where old sewers have been uncovered in Brooklyn, both in cement and vitrified pipe, in nearly every instance the vitrified pipe was shown to be broken, while there has been no case of failure by the improved cement pipe.

Concrete sewers built at Duluth, Minn., furnish a practical example of Portland cement to resist erosion. After 20 years of wear they show no appreciable deterioration or enlargement in diameter, while brick sewers laid at the same time required rebuilding after six or seven years. A section of the Duluth drains, about 2,000 feet long and 4 feet in diameter, was built on a 13 per cent grade, where the velocity of water was 42 feet per second,

with an invert of flat granite flags laid with 1:1 Portland cement joints. The flow of water during heavy storms was tremendous, carrying down with it quantities of sand and boulders, but after two years of wear the invert showed ridges of mortar between the granite flags, indicating that the Portland cement mortar was more durable than the granite.*

Advocated for Water Under Pressure.

In the United States concrete has not yet been used very extensively for conduits under high pressures, but the only point on which there can be any question as to its absolute superiority over other materials is on the permeability. Care in selecting the aggregates entering into the composition of the concrete and the fineness of the cement used are vital factors as well as thorough mixing and placing of the concrete. Tests on concrete pipes have almost invariably shown more or less leakage, but it has also been found that whatever leaks there have been at first have all gradually closed up automatically except such as are clearly traceable to faulty construction.

W. A. Grondahl, an engineer of Portland, Ore., brought forth some strong arguments for this method of construction in September, 1908, when Portland was contemplating the construction of a pipe line to supply the city with water. He said:

There can be no doubt but that reinforced concrete, if at all practicable, would give as nearly absolute permanency to the conduit as possible; and when, in addition to this, the cost of such conduit would be less than any other with the exception of wooden pipe, the consideration of its adoption will be of the greatest importance.

As to the strength of such conduit it lies absolutely with the designer to make it of any desired strength; and right here is the main advantage of the reinforced concrete pipe—if on one foot of pipe you want to provide for 1,000 pounds pressure, you put in steel to care for it; if on another foot you need only strength to overcome 100 pounds pressure, only steel enough for such pressure goes in. All of which is done simply by varying the spacing of the reinforcement rings. We all know that the strength of any structure is measured by its weakest point, and reinforced concrete is the only combination of materials which can be used in such a manner as to give absolutely equal factors of strength throughout the whole length of the line. The internal strains to be taken care of by this pipe line vary as the pipe line goes down into the ra-

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*"Concrete, Plain and Reinforced," by Taylor and Thompson.

vines and over the hills, and is measured on the profile by the distance between the hydraulic grade line and the pipe. As an illustration we will suppose that at the summit of Kelly's Butte the pipeline is up to the grade line, and thus having no internal pressure, and at the Section Line road, before turning up to reservoir No. 1, the pipe is 200 below the grade line, having 86 pounds' pressure per square inch.

A steel pipe would be made of even thickness throughout this distance, while the reinforcement in the concrete pipe might be varied with every foot—a six-foot diameter pipe which would carry the total flow of Bull Run and which would be ample to furnish water for a Portland of twice its present size would have about one-half foot thickness and weigh approximately 400 pounds per foot. A concrete pipe would have on this stretch an average of about 150 pounds of reinforcement and one-half cubic yard of concrete. The former would cost $20 per foot —the latter $12.50.

I would only add that if concrete is used as the primary substance for the building of this pipe line, a purer water supply will be given the city; the money expended will be retained at home to a much greater degree due to the fact that a larger percentage of the material and labor could be procured locally; that an equal volume could be delivered at less money or a greater volume for the same money. As to the life of the two there is no comparison. If the city of Portland builds for the future, conserving the energies of the present, having as its object pure, wholesome water, it will at least thoroughly investigate reinforced concrete.

Breakage in Shipment.

Sufficient data cannot be secured on shipments by rail of cement tile to establish any satisfactory percentage of breakage. In fact, as has been stated, one of the advantages of cement tile is the fact that it can be made close to the point where it is to be used, doing away to a large part with the necessity of long shipments. Some manufacturers have shipped a number of car loads with not a single broken tile. At other times, they have not been so fortunate and large numbers of tile have had to be replaced. In some instances, however, the fault has been so clearly with the railroad companies that they have made good the loss.

It is pretty well established that the breakage is not more than on clay tile and will probably run slightly less than 1 per cent on an average for a large number of shipments.

Manufacturers who ship tile in considerable amounts by rail prefer to cure it longer than the customary thirty days. One manufacturer says that he believes no tile should be sold under three months and he himself follows this rule almost invariably.

The following figures on shipments are given by Mr. H. J. Klemme of Belmond, Iowa: "Our experience in shipping tile has been to the extent of over 150 cars in the past nine months from distances of 10 miles up, the longest distance being between 425 and 450 miles. In this car, which was loaded one-half of 4-inch and balance 5-inch cement tile, the breakage amounted to less than 20 tile. This was, however, a remarkable shipment, considering the distance. We have shipped several cars in succession without having a tile broken; then again we will sustain severe losses. We have entered out of all our losses six claims, varying from $6.86 to $49 to the car. The sizes shipped being from 4-inch, the smallest, to 30-inch, the largest. Our greatest number were the 5, 6, 7 and 8-inch tile."

The following table is of interest as showing the amount of breakage and rejection of clay tile on a job in Minnesota. This work was done at the Northwest Experiment Farm at Crookston, Minn., on which careful records were kept of every detail. The figures given in the columns under "broken in car" and "rejected at trench" are the average number per 1,000. The tile layers were instructed to throw out all tile which were soft, cracked or ill-shaped. A crack through the walls 2 inches in depth at the end or any irregularities which would decrease the cross section of the drain or prevent its making a good joint was sufficient cause for rejection. A few cement tile were also used on this job in 4 and 5-inch sizes. The report states that these tile were straight and uniform in length and size and easily laid in the trench. These tile were, however, shipped before they had thoroughly seasoned, this fact being well understood before the shipment was made. They, however, presented about the average breakage and rejection of other tile. In fact, the 5-inch tile showed the smallest rejection at the trench, there being only 15 rejected out of 1,000. The number broken in that car was 36. This was with a haul of 342 miles. The table on clay tile is as follows:

Diamater.	Distance Shipped, miles.	Broke in car.	Rejected at Trench.
4	440	5.7	7.7
4	360	13.3	19.0
5	360	11.0	44.0
4	23	7.5	68.6
5	23	14.5	42.3
6	23	19.4	43.1
8	23	45.0	36.0

CHAPTER III.

Chemical Action of Cement in the Soil.

For an explantion of the action of cement tile in the soil from a chemical and scientific standpoint, we can do no better than to quote from a paper by Mr. C. B. McVay of Yankton, S. D., in which he says:

Portland cement is composed of more than 96 per cent of silicates, aluminates and ferrates of calcium. The remaining 3 or 4 per cent is made up of alkalies, magnesium compounds, sulphates and absorbed moisture and carbon dioxide. Mere traces of titanium, phosphorus, etc., are also present. All of these latter compounds are in such small quantities that their presence may be disregarded, and it is with the silicates, aluminates, and ferrates of calcium that we have to do. That is, with 96 or 97 per cent by weight of the Portland cement as it is supplied to the user.

The tile manufacturer mixes in certain proportions the cement, sand and gravel and to the whole adds water in sufficient amount to change the calcium compounds named above into hydrates of these compounds. The hydrates are in the form of crystals and colloids, and when the hydrating process is completed we have a matrix of crystals and colloids holding together the sand particles and gravel, the whole forming a mass of great hardness and strength. This is concrete.

Since the sand and gravel have for many ages been in contact with the soil and subjected to the action of water, it only remains to show that this matrix of crystals and colloids, which bonds the sand particles and gravel into a solid mass, is indestructible by natural forces, in order to prove that in well made Portland cement drainage tile we have a material that will still be intact and do its work for generations to come.

The basic element of this matrix is calcium, or lime, and while lime as lime hydrate (common slacked lime) is quite soluble in water, it is practically insoluble in the form of hydrated silicates, aluminates and ferrates which compose the matrix.

Water that has been in the soil for some time has already become saturated with soluble mineral salts; and rain water, which has considerable power as a solvent, always contains carbon dioxide. Let us see what effect this would have on our tile. The concrete being more or less porous, it readily passes the water through its interstices. We will grant that the cement contains a small percentage of soluble lime; we will also grant the slight solubility of hydrated calcium silicate, aluminate and ferrate. What is the result? The carbon dioxide in the water precipitates the lime as carbonate, which fills the pores of the concrete, arresting further

action by the water. It is this principle that renders concrete when exposed to the weather more and more impermeable to moisture as the years pass and which, of course, will in time make our tile too dense to take water except at the joints.

In his work on "Beton and Reinforced Concrete," Mr. Tedesco, speaking of the influence of various substances upon cement, states that it is particularly susceptible, in its powdered state, to acids; that it is a well-known fact that carbonic acid will destroy powdered cement and a large amount of sulphuric acid will have similar results, but he goes on to say that when the cement is hardened it is little sensible to acids or other chemical agencies.

When a mortar is well compacted and the pores are closed, it becomes largely free from any attack of this kind. Mr. Tedesco goes on to say that a hardened cement does not resist energetic acids which acting on the lime may form soluble chlorides, acetates, etc., but such acids as sulphuric acid, sulphurous acid and sulphuretted acid are little to be feared because they form insoluble or difficult salts, or salts that are soluble with great difficulty. In such cases they form a sort of a coating which protects the cement against the exterior influence of these acids.

Action of Alkali.

While the contention is made that cement pipe and tile if properly manufactured will withstand any conditions of acid or alkali likely to be found in nature, or in manufactures, arts, etc., it is but fair to assume, as one or two results seem to indicate, that conditions may arise under which cement pipe and tile would disintegrate. The instance of this kind which has received most publicity has come up in connection with the work of the Reclamation Service in certain sections of the West, where the soil is heavily charged with alkali. The whole matter is now being investigated at the Government laboratories, and until the report of these investigations is ready for the public, any "snap judgment" is manifestly unfair.

It should be noted, however, as pointed out by *Engineering News*, that concrete in an alkali country is generally made of alkali-bearing materials. The preliminary report of the Reclamation Service shows a sand high in soluble salts and doubtless the mixing water was of like composition. This is a real source of danger, because thereby the attacking salts are introduced into the interior of the mass and it is quite certain that chemically active elements have a much more pronounced effect upon a setting

concrete than upon one which has reached a final set. In addition to a dense mixture, therefore, care should be taken to avoid alkali-bearing material in the concrete.

Granting, however, that a few localities may be found where the soil is so highly charged with alkali as to shorten the life of cement tile as at present manufactured, it will not be a difficult matter for the laboratories of the cement companies to so compound their product that this may be successfully overcome. In fact, it can be stated that some of the cement companies are studying this whole matter as carefully as any other experts, with a view to making their product highly applicable to the purpose for which it is to be used.

Richard K. Meade, of the Meade Testing Laboratories, Nazareth, Pa., says: "It is probable that in some localities there are substances in the soil which would attack concrete if the latter is made very porous. In this case the remedy is obvious and all that is needed to overcome it is a denser concrete or the addition of some waterproofing substance to the concrete to keep the harmful solutions out of the concrete."

The subject of the action of alkali waters upon cement and concrete products is commented upon by Fred W. Brown, Denver, Colo., in *Mining Science*, published in that city. Mr. Brown says:

It is of the utmost importance here in the West that this matter be clearly understood, and that practical means of prevention be employed, if the people are to enjoy the utilities and economies of concrete construction as they should.

It is simply an old problem presented under new conditions. Exhaustive tests have shown that more than 2.5 per cent of sulphuric acid in combination as soluble salts in Portland cement is injurious to some cements. Standard specifications in this country limit manufacturers to 1.75 per cent, while 2.5 per cent is perfectly safe. Some cements will stand much higher percentages than others. Cements high in their percentage of lime, free magnesia, or free alkali, are much the more readily attacked. A Portland cement of high quality of minimum content in lime, and practically no free magnesia or alkali, will stand the addition of 25 per cent of sulphate of lime without failure in water. This is a practical indication of its ability to stand in soils of the character described at Great Falls, in the Montana Experiment Station report. Cements suitable for use in such places should be especially designed for such purpose by careful consideration of these points and special manufacture if not otherwise obtainable.

In western parlance, the term "alkali" is a general one used to designate any soluble salt in the soil which makes its appearance on the surface as a gray or white efflorescence on leaching

with water. This substance varies greatly in its percentage content of the following salts:

Sulphate of Lime.
Sulphate of Magnesia.
Sulphate of Soda.
Sulphate of Alumina.
Sulphate of Iron
Sulphate of Potash.
Carbonate of Soda.
Carbonate of Potash.
Chloride of Soda.
Nitrate of Soda.

Of these, it is only the sulphates that prove injurious.

These sulphates are common throughout the shales of the Dakota formations. Of these, the sulphates of iron and alumina are practically negligible as they become decomposed in the portions of the soil that are weathered and occur at depths, and are brought out only by the mineral waters.

Thus our sources of the injurious sulphuric acid are limited to the first three substances. Of these the sulphate of lime is much the most insoluble, and consequently the least dangerous.

If the manufacturer of cement limits the sulphuric acid in his cement to far below the danger point, the manufacturer of concrete must also limit the amount of sulphuric acid that can be present in his concrete to an amount below the danger limit. Both classes of manufacturers are supposed to do this.

The failure to do so on the part of the manufacturer of concrete has occurred because he did not understand his conditions.

When an engineer has charge of construction in a country which gives indication of "alkali" he should learn the character of his soil, and if it is a shale, or sand, or lime, of jurassic, cretaceous or tertiary formation, he should have small portions of it leached, and the leaching water evaporated to determine if it contains bitter salts. If so, he must guard against the following contingency:

If a body of concrete, or mortar, is to be interposed between such soils, which may contain water at some time, and the atmosphere, he must make one, or both, of two provisions:

First—He must provide such drainage for his ground waters that they will have no opportunity to permeate his concrete and evaporate into the air; or,

Second—He must make his concrete sufficiently dense and impervious that the pores of the same cannot contain sufficient sulphates to decompose the concrete.

The cause of the deposition of the sulphuric acid salts in the pores of the concrete is atmospheric evaporation of the water from one surface, which comes into the concrete from the other surface, charged with the salts in solution. The water itself does not carry enough salts in solution to destroy the concrete if it flows through the concrete, or if the concrete were submerged, but if the evaporation occurs from the concrete, and there are pores enough in the

concrete to accumulate them, it is only a question of time until the concrete will be replaced by the soluble salts and sand.

It is urged that the concrete should stand the action of these salts or it is worthless. I answer, that no other known material will permanently withstand their action under the same conditions. Sandstone and granite would be decomposed. Limestone would be dissolved. Iron and copper would be dissolved or rusted away.

As far as the action of these soluble sulphates on cement is concerned it is sufficient to explain that the early strength of cement is obtained by the hydration of excess lime, which is so burned that it crystalizes on combination with water instead of swelling as quicklime does. In this crystalline state it is insoluble in water. But when its pores become charged with sulphates which are unstable in themselves, and which have the power of changing molecular form by combination with larger or smaller amounts of water, of crystallization under varying conditions of air and water, these sulphates break up the combination of the crystalline lime with water, by appropriation of the water themselves, thus causing the lime to swell in presence of moisture as it ordinarily does on hydrating, after which it becomes soluble lime, and gives no strength to the concrete, and may eventually be carried away in solution.

The great trouble in the instances described in the report has been that the concrete, or mortar, was porous; the aggregates were not properly selected, sized and proportioned, and so mixed into a soft pulp, and so deposited as to give an impervious layer of mortar on the exterior and interior surfaces of the concrete, or around the brick. When this is properly done and proper cement used, all underground concrete work will be found to withstand permanently the action of these alkalies.

The statement was made by Mr. Richard L. Humphrey before the Iowa Association of Cement Users that the degree of solubility of cement in water is so slight as to make it an unimportant item. "A compound such as Portland cement is very complex and the subject of many conditions," he asserted. "The very process of crystallization is one which liberates some lime or soluble salts, and those salts unquestionably are soluble in water; but the real material that is in that mass is permanent, and for all practical purposes insoluble under the conditions to which Portland cement concrete is ever subjected. In the case of a porous drain tile, where water percolates through, I have no doubt that there may be some evidences of lime dissolved out of that mass, but it does not in any way take from the strength of the material. The real hardening compounds in Portland cement, which give it strength and durability are there to stay, and it is not true that Portland cement concrete, properly made, is perishable."

Mr. Humphrey at the same time gave an instance of the class

of scares which are being sprung in regard to alkali soils. He said: "Not long ago concrete was laid in the form of a sewer in a section of the country where the water was very highly charged with alkalies. In a short time it was found that the material had corroded to the extent of half an inch. They were very much alarmed and wanted an investigation of the water to find out what it was that caused the disintegration. Instead of examining the water I examined the engineer to find out the conditions. I found the work was about four months old; that it had been laid in a temperature not exceeding thirty-six degrees and was not really set. That shortly afterward a flood had come up, bringing down a great deal of stone and other materials, and they had rubbed away the green concrete. Yet the fault was charged to the salts in the water.

"It only goes to show the fear that people have of Portland cement. In other words, if a structure fails there can be only one cause of failure; the cement that was used. In case of these cement tile I have no doubt that it is true to some extent that the material will go to pieces by the action of the water, but it is many times stronger than the ordinary clay tile, which is its chief competitor. As far as frost is concerned, it will stand where ordinary clay tile will disintegrate."

CHAPTER IV.

The Clay Tile Controversy.

Judging from some of the arguments against cement pipe and tile which its opponents bring forth, one would be justified in supposing that the manufacture of these products in clay had been reduced to an exact art. Such is, however, far from the case. There are in the clay tile industry problems of selection of materials, of mixing and, above all, of burning.

The selection and combination of materials is a far more delicate question with the clay man that the one who works in cement. The latter gets the active agent of his product delivered to his door ready prepared. The selection of materials, so far as their chemical action is concerned, has been done for him in the laboratory of the cement mill, where the production of thousands of barrels daily makes it possible to employ the best chemical supervision obtainable. He has only to add an inactive ingredient, a "filler," which has to be given but slight attention as to its general physical characteristics.

The manufacturer of clay tile is working usually on a smaller scale than the cement manufacturer, his product bulks large, but sells small, and the selection and mixing of his ingredients cannot be carried on with the same care. As an illustration of this point it can be said that it would be impossible to establish a national standard for clay products and have them lived up to, such as the rigid specifications which cement is required to pass.

In the matter of curing, cement tile has large advantages, both economically and otherwise. The clay product must first be dried, then put in the kiln and baked. This means two handlings where cement tile requires but one; it also means a large expense for kilns, fuel, etc. But this is not all. The process of burning is a gamble not equaled by any stage of the manufacture of the cement product. The man who can carry a number of kilns through without a considerable percentage of loss is hard to find, and he is worth almost his own price.

On first entering the kiln the tile are "water smoked"; that is, they are given a comparatively small amount of heat for a number

of hours, until all water which they contain has been driven out the stack in the form of vapor. This sounds simple, but the man who does the work thinks otherwise. The clay may contain more moisture than was supposed, and when this is brought out by the heat many of them may settle down into a shapeless mass. Worse still, individual tile may topple over against their neighbors, carrying down whole rows to destruction, like the row of dominoes which the small boy delights in knocking over by setting a single one in motion.

Then the tile must be burned. But different mixtures of clay will require different intensities of heat; different parts of the kiln will be differently heated, over burning parts of the contents and under burning other parts.

Compared with this process the curing of cement tile is certainly a simple and economical matter. No heat is required, unless it be for heating the curing sheds in winter time. Even when the steam curing process is used, such a low grade of steam is required that the exhaust from the engine is found sufficient. If the tile reach the curing shelves well made and in proper shape their success is practically assured. With the aid of a little water or steam, nature herself will carry on the work of finishing the product. If a tile occasionally goes down it falls flat as a usual thing, breaking at most only one or two of its nearest neighbors.

One of the Chief Objectors.

One of the most active opponents of cement tile is Mr. G. G. Wheat of Emmetsburg, Iowa, who read a paper before the Iowa Brick and Tile Association, January 23, 1908, which was widely circulated and which, together with later utterances from the same source, has been adopted as a sort of classic, supposedly embodying everything to be said on the subject.

Mr. Wheat's argument is entirely destructive. While citing several examples to support his theory regarding cement, he offers nothing in contrast to show the superiority of clay tile. Evidently assuming that all cement concrete is of one grade, he proceeds to take for his illustrations examples of poor workmanship, drawing the broad conclusion that all concrete will fail under similar conditions.

The anti-cement tile argument, as presented by Mr. Wheat, may be reduced to three propositions, as follows: First, cement is soluble; second, cement meets harder conditions of service when used in drain tile than anywhere else; third, where cement

tile factories have been established, clay tile has been practically driven out of the field. Incidentally it may be noted that Mr. Wheat is manager of a clay tile factory in northern Iowa, where the use of cement tile is increasing rapidly. As corollary to the first proposition, he states that complete solution of the cement matrix may take place in from six to ten years, and that perfectly set cement will undergo transformation and loss in solution. From the second proposition it follows that the matrix will wash away and leave only a shell of sand (although not a shred of evidence is given to bolster up this contention), and that the use of cement tile so extensively threatens great harm eventually to drainage works. As to the third proposition no corollary is stated, but this one is obvious; there must be a reason for the preference for cement tile.

Mr. Wheat endeavors to support his argument by numerous illustrations which will not stand analysis, but the mere statement is harmful because many people believe what they see in print. An instance of the wrong inferences drawn by Mr. Wheat is the following: Thirty years ago a man living in Illinois built an ornamental fence of Portland cement concrete. Fifteen years ago the fence was still standing and the pride of its owner. Last year the fence was not to be found; therefore, it had rotted away. Therefore, cement is not a lasting material. No inquiry into the true cause for removing the fence appears to have been made.

In this address, Mr. Wheat offers no evidence of a single failure of cement drainage tile, although many miles of such tile have been laid in his neighborhood. Instead, he bases his conclusions on observations of concrete curbs, fence posts and cisterns. Against one piece of curb in which the aggregate is exposed, because the wormanship was poor, may be cited innumerable cases in all parts of the country where the curb, being properly made, has stood for years and is today as good as ever. An Iowa druggist built a fence with cement posts, but it lasted only five years, says Mr. Wheat. It is assumed that this druggist know how to make concrete posts as they should be made, used proper materials in correct proportions, and put in good workmanship. The feebleness of this illustration must have been felt by Mr. Wheat for perhaps inadvertantly he defends cement posts in these words: "Concrete fence posts have been used in many places and to draw illustrations from them must not be construed as any argument against

CLAY TILE WHICH HAS GONE TO PIECES FROM EXPOSURE, AND CEMENT TILE WHICH HAS BEEN IN USE TWO YEARS.

cement fence posts." Thus does he knock out the prop from under part of his argument.

Attention is drawn to the alleged failure of the concrete water table in the Palo Alto county court house at Emmetsburg, Ia. The claim is made that the projecting corners have disintegrated because subjected to an excessive flow of water. A photograph was shown with this comment: "The material was improperly mixed and the poorer part dissolved first." There is the answer—imperfect mixing. An investigation of this water table discloses some facts which Mr. Wheat failed to mention or to observe and are of interest. The building was erected in 1880. The corner stone, which is of limestone, is badly weather-worn, but the cement water table above it is in excellent condition. It is also noticeable that the limestone window caps are going to pieces, while the cement water table over them is absolutely sound. Unfortunately among the blocks in the water table are a few pieces showing poor workmanship, and so obviously is this the case that even Mr. Wheat has admitted the concrete was imperfectly mixed. Across the street from the court house is a hotel built the following year and which has concrete trimmings in perfect condition. These trimmings are remarkable as early examples of molding ornaments in concrete.

Again we learn that "There is and can be no such thing as a good cement drain. Even if it were all cement it would dissolve and carry away in one generation." We are expected to take this statement seriously. The claim that in six to ten years the cement bond is destroyed in such construction as cisterns and tile drains is based on a laboratory test of a fragment of concrete weighing 73 grams, which lost .0324 grams after soaking 72 hours in distilled water and .0039 grams after soaking 74 hours in city water. As the concrete was a 1:3 mixture, Mr. Wheat argues that it would lose all its cement in about six years. This deduction is not warranted by any means. The test should have been repeated several times on the same sample for check results. It must be granted that a portion of the cement is soluable, but not all of it. The amount of the sample dissolved was decreasing rapidly with each trial, yet Mr. Wheat assumed that it would continue uniformly. The amount stated to have been successively dissolved per hour were .000452, .000335, .000411 and .000053 grams. The first and third tests were made with distilled water and show a falling off of 10 per cent, the second and fourth made with city water show a de-

crease of 84 per cent. The distilled water tests are not comparable with practical conditions, since ground waters always carry impurities in solution. The durability of cement is established by years of use on the spillways of dams and ancient aqueducts. When perfectly set, it is as lasting as stone. Mr. Wheat even admits that "Many instances of cement lasting for decades in sea wall construction can be found."

Thus we come to Mr. Wheat's third proposition which appears to be the nub of the whole matter, namely, that cement tile is killing the clay tile business. We have no reason to doubt this conclusion, and Mr. Wheat is certainly in a position to know.

Of course, our friend from Emmetsburg is naturally concerned in the fact that he has on his hands a clay tile plant which cost $40,000 or more, while all around him people are making cement tile which can be sold at the same price, which gives absolutely as good satisfaction, with an initial investment of a small part of that sum. On these grounds no one blames him for attempting to create a sentiment in the public mind friendly to his own product. It is very much, however, like the campaign which was made a few years ago in favor of cream of tartar baking powder. The cream of tartar men had their supply of materials contracted for for several years to come, and in the face of a new discovery they were compelled either to create a public sentiment in their favor or go out of business.

When this manufacturer comes out, however, and takes a position as defender of the rights and pocketbooks of the people, his position becomes truly ridiculous. The words which he puts into the mouth of a "prominent attorney" are certainly woeful indeed: "To confiscate the farms of men who have their all invested in their little homes and to give them nothing for their money in return is a public shame."

We should like, however, to have this doughty defender of the people's rights explain why it is that in a nearby county the tile interests have secured such control of county officials that they refuse to consider an estimate on cement tile.

We should like him to explain why in that county on a certain piece of drainage work an estimate which contemplated the use of cement tile at $14,000 was given no consideration, while the work was awarded to the clay tile interests at $23,000.

We should like him to explain whether or not it is in the

interests of the beloved farmer that the clay tile men are con ducting drainage work practically in their own way in this county, running the farmers' assessments up in some cases as high as $40 per acre.

We should be glad of an explanation, also, of the fact that the man who is acting as county engineer, a man who has a thorough engineering training and is well acquainted with the merits of cement tile, dare not recommend it on any county work for fear of losing his job.

We should also like to know why it is that another man who is engaged on county work dares scarcely so much as mention cement tile in his own county, although himself interested in the cement tile business in a distant county.

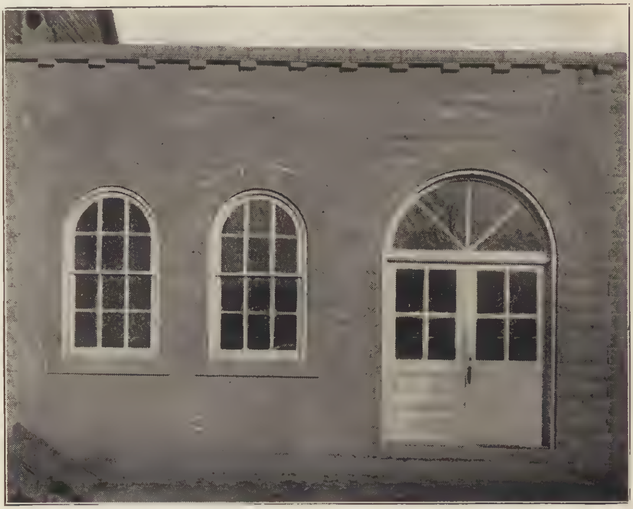
Mr. Wheat, writing in *Brick,* shows photographs of cement tile which have gone to pieces, and it will be of interest to know the exact history of this tile, as was learned by the present writer. This tile is a short distance from Emmetsburg, Iowa, and was hauled out to the location of the ditch over two years ago. Through some complications which arose, the ditch was not dug at that time and the tile consequently lay out in a slough for two years, very largely covered with water and alternately freezing and thawing. Of course, no tile would go through such an experience as that unscathed. As a matter of fact, there was a considerable amount of tile which came through this experience in perfect condition, showing no breakage, cracking or disintegration. Under the circumstances it was an unusual thing that any of the tile should have come out whole, and it was a test which the clay tile man would not care to have applied to his own product. During the past summer, the ditch was dug and new tile were laid and covered with a few inches of blinding. On top of this blinding were thrown pieces of old tile in order to keep the soil loose and assist in the drainage. While the ditch was in this stage, the clay man's photographer came along and photographed it, and the photograph is given out as showing the inevitable end of cement tile.

The unbiased student of the subject will do well to compare with them a couple of photographs which are reproduced herewith, showing clay tile which has passed through similar conditions. In the same photographs are shown cement tile which was taken out of the ground after two years, showing not the slightest defect.

This writer also has in his possession a piece of clay tile which

will make a valuable exhibit to anyone interested in this controversy. It was secured at Armstrong, Iowa, in company with the man who selected and laid the tile. It was at the outfall of a drain, for which a Monmouth vitrified tile of apparent exceptional quality was chosen. In its present condition, however, it is badly cracked and disintegrated, so that a piece was easily broken away. At the bottom of the drain, where sediment settles, the tile is becoming soft and shows unmistakable signs of rotting, although having been in use but a very few years.

Just as this chapter is being written we are advised of some correspondence which recently passed between Prof. Ira O.



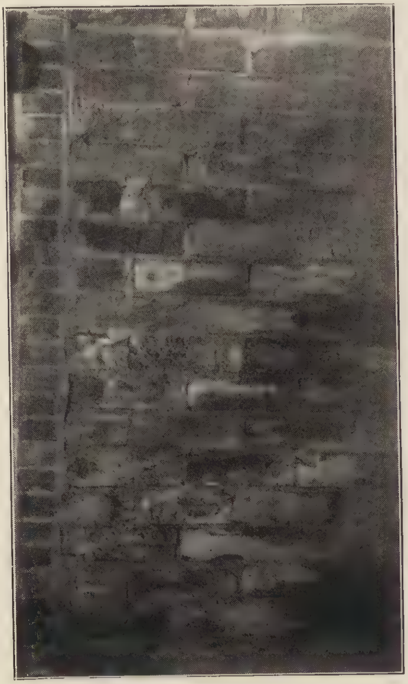
FRONT OF BLACKSMITH SHOP—CONCRETE BLOCKS—IN PERFECT CONDITION.

Baker of the University of Illinois and a firm of cement tile manufacturers. Professor Baker's professional standing is well known, and he ought to be relied upon to know whereof he speaks. Asked by the tile manufacturer regarding the qualities of cement tile, Professor Baker wrote:

"I do not think there is any reason to worry about concrete drain tile deteriorating after being laid. I know that someone has written a scare article on that subject, but his alleged facts were ridiculous and his logic erroneous. There are no acids in

the soil that will appreciably if at all affect the durability of cement drain tile."

Professor Baker evidently refers to our writer in *Brick* when he states that "his alleged facts were ridiculous and his logic erroneous." He certainly has our thanks for bringing the weight of his opinion into this controversy just at this time.



INTERIOR OF SIDE WALL OF BLACKSMITH SHOP—CLAY BLOCKS.

Another pet diversion of the clay tile man is to find a crack or other defect in a cement wall, post or other cement product, and hold it up as a horrible example of the effect of departing from the beaten path which the clay man has mapped out. Sometimes his own statement shows that the work was improperly done, or done under conditions which no good concrete man will permit. But it is all the same to him —he is being paid to get such stuff, and he has to deliver the goods. Just to meet him on his own ground, therefore, we might depart for a moment from a discussion of the tile problem to show three photographs taken by this scribe at Webster City, Iowa.

The history connected with them is this: Something over a year ago a blacksmith of Webster City decided to put up a new shop. Being an intelligent, progressive blacksmith, he determined upon concrete blocks as the proper building material, and he had his order practically placed with the block man. At that juncture along came the clay man, who is accustomed to having things go pretty much as he dictates in that county. He was so insistent that the blacksmith, whose inter-

est alone the clay man was undoubtedly anxious to conserve (?) made a compromise by building the front of his shop of concrete blocks and the other walls of hollow clay blocks.

Under the circumstances, the two coming into such close comparison as they do, one would suppose that a special effort would have been made by the clay men to put up a creditable showing. The photographs tell the story, however. One of them shows the concrete front, every block perfect and without a flaw of any kind; the other two show the inside and outside

EXTERIOR OF SIDE WALL OF BLACKSMITH SHOP—CLAY BLOCKS.

of one of the side walls. It can be plainly seen, even in this work of an amateur photographer, that the blocks are badly scaled and spalled off. On the outside of the wall it will be seen that one of the blocks has disintegrated so badly that the outer shell has entirely broken away. Higher up on the wall can be seen a place where a similar hole has been plastered over. Many of the blocks are so soft that large parts of them can be rubbed away in the form of powder by the fingers. The imperfect condition of some of the blocks on the pile to the left of the engraving can also be plainly seen.

This blacksmith is now disposed to call himself all kinds of uncomplimentary names for the compromise which he made.

But the pathetic part of it all is that no amount of regret or self-accusation will bring his money back.

Sewers at Oshkosh.

Mr. Wheat cited in some of his utterances the failure of cement pipe at Oshkosh, Wis. Thereupon Mr. E. S. Larned of Boston wrote to G. H. Randall, city engineer of Oshkosh, asking for the facts of the case. The following is his reply, as published in Bulletin No. 19 of the Association of American Portland Cement Manufacturers:

The article in *Brick* was not true, and their conclusions were certainly wrong. I don't believe a single foot of cement pipe failed in this town from the action of acids. Almost all of the trouble we had here was caused by insufficient covering of the pipe; they froze and were broken by expansion of ice or disintegrated by freezing and thawing.

Between 1892-1896 cement pipe were poorly made. The company that made the pipe used Portland cement and natural cement mixed with sand and gravel. The sand and gravel were of good material.

In the first place natural cement should not be used with Portland; in the second place, there was a very small portion of Portland cement used.

Cement pipe were first used here in 1884. My father was engineer and I was his assistant. Between 1884 and 1892 the pipe were much better and we have all of these sewers in use today except a few streets where we took them up to enlage them.

The first cement sewers are in the business and thickly settled portions of the city, and although natural cement was used in their manufacture, they are in good condition today. We are tapping them every day, and the workmen say the first sewers are in fine condition. Now, this is the district where sewer acids would destroy the pipe, if anywhere.

I don't know of any place in Oshkosh where cement pipe have failed that vitrified pipe would not have failed. In the first place, I think 1,000 feet would cover all the pipe of cement that had to be replaced because it had broken down, and that was broken by the steam roller because of the telford foundation resting on the top of the pipe or from freezing.

Our sewer system is the combined system, and sewerage proper (that is, the solids) is well flushed by the storm water. Our cement pipe are not what they ought to be, but considering the conditions I think it wonderful we had had so little trouble. We have had to replace over 1,200 feet of vitrified pipe that went to pieces where there was no excuse for it, except poor pipe.

From the same Bulletin is also taken the following letter from

Mr. F. W. Burt, of the Rhode Island Cement Drain Pipe Company, Providence, R. I.:

Our city engineers have been somewhat prejudiced against cement and have not used it very much in what they call permanent sewers, but Rhode Island is a great manufacturing state and every town has several factories. To them we have sold quantities of cement pipe with satisfaction. The Atlantic Mills at Olneyville have over 3,000 feet of our 20x30-inch oval pipe that was put in about thirty-seven years ago. It was to carry off the expended dyes from the coloring vats. This dye is composed of acids, salts, potash, etc., and was discharged in the pipe at or near the scalding point. After it had been in use eighteen years, the city had occasion to remove two or three pieces in putting in water pipes and the cement was in almost as good condition as when put in. The inside did show a wearing out of the cement, leaving the pebbles a little more prominent, possibly about 1/32 of an inch in depth.

The top was stained with coloring, showing that it had run full at times. I think it is still in use. It speaks well for cement pipe. But it is well to bear in mind that this pipe was made of natural cement. Had it been made of Portland cement as it is made today it would have showed little if any wear. For the last ten years we have been putting a little Portland cement in all of of our pipe and as the price of Portland has gone down, we have added more, until now we are using all Portland, and the result is a better pipe for the same money. Cement stands the fill much better than clay pipe; it can be laid near the top of the ground with safety.

Professor Orton Answered.

Reference has been made to a letter written by Prof. Orton, which is being widely circulated. The substance of the letter is that cement drain tile "is exposed persistently to the very influence under which it most rapidly deteriorates," namely, "the solvent power of water more or less saturated with carbon dioxide" and organic acids which "tend to leach out lime" while "the constant filtration of air through its walls into the soil" "tends to oxidize the sulphides in the cement into soluble sulphates" and finally that the soundness and qualities of cement pipe cannot be told by the appearance. Those are bare statements and as the context shows are purely theoretical. They assume a state of affairs which never exists. In the first place, drainage water in farming communities is very far indeed from being saturated with carbon dioxide, which is, by the way, the weakest of all acids. Typical analysis of drainage water from cultivated fields are given by the United States Department of Agriculture, Bureau of Soils Bulletin No. 26, "Investigations in

Soil Management, pages 23 and 77. The average from twelve wheat fields shows only 53.5 parts of carbonic acid and 32.7 parts of organic matter in 1,000,000 parts of drain water, and the worst sample taken from a drain under a black marsh soil gave only 340.6 parts of carbonic acid in 1,000,000 of water. The average amount of carbonic acid in ground water and open ditches is less than three parts in 1,000,000. The chemical activity of such exceedingly weak solutions is trifling and is not liable to attack the tile because of possible neutralization of the acid by lime in the soil. The analyses show three times as much lime as carbonic acid in solution, and carbonic acid would re-act with lime already in solution before it would attack solid lime in a tile.

The professor should also have shown that sulphides are either entirely absent from cement or present in such a minute quantity as to be negligible, and the percentage of sulphates is also so small that every particle could be leached out after the concrete has set without weakening it. That air should be constantly filtering through a tile in one direction, while water is constantly filtering through it in the opposite direction is almost too absurd to notice. Air cannot go through the tile unless there is a difference in pressure, but since the pressure inside the tile cannot be greater than that of the atmosphere, it would be necessary to assume a partial vacuum on the outside. Actually the pressure outside is greater than atmospheric by the length of a column of water between the tile and the ground water level unless the ground water is below the tile, when the pressure is the same on both sides. Finally it is difficult to see why the professor should think it is more difficult to tell a sound tile of cement than of clay. It is entirely a matter of experience on the part of the inspector.

CHAPTER V.

Result of Tests.

While a number of tests of cement tile are now in progress, and are expected to add a large fund of information to the literature of this subject, the most important tests which have so far been completed and tabulated are those conducted in the early part of 1907, at the Engineering Experiment Station of Iowa State College, Ames, Iowa. These tests were made by two senior students of the College of Engineering, under direction of Prof. A. Marston, Dean of the College.

It was necessary at the outset to determine upon a method of conducting the test which would approximate actual conditions as closely as possible.

As tile and sewer pipe are actually used in the ditch, the bottom of it does not exactly conform to the lower half of the pipe, and there is a tendency for the earth to settle away from the under side at the outer portions, leaving the pipe unsupported there. At the mid-diameter, in a narrow ditch, or with careless tamping, there is also lack of support from the earth filling. The load comes upon the upper half of the pipe from the weight of superincumbent filling, but this will receive some support by friction against the sides of the ditch.

After careful consideration of these conditions, it was decided that the best standard method easily capable of duplication in any laboratory, and which should approximately represent actual service conditions, would be to bend the lower portion of the pipe for one-quarter of the entire circumference in sand, retained firmly in place by a heavy framework of timber, and to apply the load to the upper portion through a similar bed of sand, extending one-fourth of the entire circumference of the pipe, and all held in place by a heavy frame work of timber. A thickness of cloth or canvas was used to prevent the sand from escaping between the edge of the upper framework and the pipe. The pressure was applied to the upper surface of the bed of sand and not to the upper framework. There was no danger, therefore, of concentrated pressure coming upon the pipe through contact with the upper frame.

The tests were made on a 100,000-pound transverse Riehle testing machine.

General Plan of Investigation.

A number of samples of drain tile were secured from manufacturers as representative of their product, in the case of both cement and clay. The cement tile so obtained ranged from 4 to 12 inches. The clay tile, on the other hand, ranged from 4 to 24 inches internal diameter. Besides testing the above samples obtained from manufacturers, it was thought desirable to manufacture

TESTS OF STRENGTH OF 12 TO 20-INCH CEMENT DRAIN TILE.

Propor. C.	S.	Dimensions, ins. L.	D.	T.	Str. load per lin. in. 2 months.	11 months.	Remarks.
1	3	24	20	2¼	89	69	Cracked.
1	3	24	20	2¼	73		
1	3	24	20	1¾	68	142	
1	3	24	20	1¾	70	175	1½ in. shell.
1	3	24	18	2¼	115	315	2 in. shell.
1	3	24	18	2¼	141	299	2 in. shell.
1	3	24	18	1¾	109	221	1½ in. shell.
1	3	24	18	1¾	79	81	Cracked.
1	3	24	12	2	116	365	
1	3	24	12	2	155	470	2¼ in. shell.
1	3	24	12	1½	135	181	
1	3	24	12	1½	99	218	
		24	12	1½	95		
		24	12	1½	125		
		24	12	1¼	58		Under tamped.

TESTS OF STRENGTH OF 12 TO 24-INCH CLAY DRAIN TILE.

Made at	Degree of Fusion.	Dimensions, ins. L.	D.	T.	Load., lin. ft.	Remarks.
Des Moines	Vitrified	24	24	2⅛	318	
Des Moines	Vitrified	24	18½	1¼	212	
Des Moines	Vitrified	24	18½	1¼	187	
Mason City	Semi-vitrified	27	18½	1⅛	96	Badly Checked
Mason City	Semi-vitrified	27	17½	1	89	Checked
Mason City	Semi-vitrified	27	15	1	64	Badly Checked
Mason City	Semi-vitrified	27	15	1	103	
Des Moines	Vitrified	12	12	⅞	168	
Des Moines	Vitrified	12	12	⅞	117	
Mason City	Semi-vitrified	12	12	⅞	158	
Storm Lake	Soft burned	12	12	⅞	151	
Storm Lake	Soft burned	12	10	1	98	

some cement tile, so that accurate information would be available as to the proportions of sand and cement and all other features of the manufacture.

A 1:3 mixture was adopted for these tile. The material was of good, coarse sand, containing some small pebbles. The tiles

were made in Miracle molds by the ordinary dry process, the details being directed by an experienced tile maker. The work was done in the month of March, in the basement of one of the college buildings which was under construction. The tile were protected against freezing, but were not kept at a very high temperature. They were kept thoroughly sprinkled with water until set hard. The internal diameters of tile manufactured were 12, 18 and 20 inches, respectively.

After making a complete set of tile of the regular thicknesses

TESTS OF STRENGTH OF 4 TO 12-INCH CEMENT DRAIN TILE.

Made at	Proper C.	Proper S.	Dimensions, ins L	D	T	Age.	Load per. lin. in.
Sherburn	1	5	12	12	1		98
Sherburn	1	5	12	12	1		115
Emmettsburg	1	4	12	10	7/8	6 months	106
Sherburn	1	4	12	8	3/4		97
Emmettsburg	1	4	12	8	3/4	6 months	71
Emmettsburg	1	4	12	8	3/4		74
Sherburn	1	5	12	7	3/4		99
	1	5	12	7	3/4		177
	1	6	12	6	5/8		
	1	5	12	6	5/8		66
	1	5	12	6	5/8		73
	1	3	12	5	5/8		97
	1	5	12	5	5/8		82
	1	5	12	4	5/8		98
	1	5	12	4	5/8		80

TESTS OF STRENGTH OF 4 TO 10-INCH CLAY DRAIN TILE.

Made at	**Degree of fusion.**	**Dimensions, ins. L.**	**D.**	**T.**	**Load per. lin. in.**
Mason City	**Semi-vitrified**	**12**	**10**	**7/8**	**117**
Mason City	**Semi-vitrified**	**12**	**10**	**7/8**	**127**
Mason City	**Semi-vitrified**	**12**	**10**	**3/4**	**102**
Mason City	**Semi-vitrified**	**12**	**8**	**3/4**	**134**
Storm Lake	**Soft burned**	**12**	**8**	**3/4**	**98**
Storm Lake	**Soft burned**	**12**	**8**	**3/4**	**103**
Storm Lake	**Soft burned**	**12**	**8**	**3/4**	**118**
Storm Lake	**Soft burned**	**12**	**6**	**3/4**	**125**
Storm Lake	**Soft burned**	**12**	**6**	**3/4**	**106**
Des Moines	**Vitrified**	**12**	**6**	**5/8**	**160**
Des Moines	**Vitrified**	**12**	**6**	**5/8**	**150**
Mason City	**Semi-vitrified**	**12**	**6**	**5/8**	**90**
Mason City	**Semi-vitrified**	**12**	**6**	**5/8**	**128**
Mason City	**Semi-vitrified**	**12**	**6**	**1/2**	**123**
Mason City	**Semi-vitrified**	**12**	**4**	**1/2**	**141**

provided for by the Miracle molds, these molds were remodeled in the shops and a second set of tile manufactured, having about ½ inch greater thickness of shell than the first.

Result of Tests.

The results of the tests are shown in the tables herewith. In these tables C means cement, L length, S sand, D diameter and T thickness.

What the Tests Show.

Shortly after these tests were completed Professor Marston summarized them in an address before the Iowa Association of Cement Users, published in the *Iowa Engineer* of March, 1908, in which he said:

In attempting to draw conclusions from these results, it should be remembered that tests of clay and cement materials show large variation due to unavoidable differences in manufacture, and hence not too much reliance should be placed upon the results of so small a number of tests as are given in the above tables Perhaps the most striking feature in connection with these tests is the great increase of strength from two months to eleven months in the age of the cement tile manufactured at the college. In this connection it should be remembered that the weather was cool during the first two months these were cured. The increase in strength is shown in the table following:

PER CENT OF INCREASE IN STRENGTH OF CEMENT DRAIN TILE BETWEEN THE AGE OF TWO MONTHS AND ELEVEN MONTHS.

Diameter—	Per Cent of Increase.
20 in. thin	130
18 in. thick	140
18 in. thin	136
12 in. thick	205
12 in. thin	71

One good quality of cement drain tile is that they continue to increase in strength after first manufactured. Unfortunately, however, the heaviest pressures come upon them soon after they are laid. It would not seem wise, therefore, to use cement tile very soon after manufacture.

Theoretically the strength of cement drain tile per lineal inch should be in proportion to the square of the thickness of the shell. In these tests this law is obscured, possibly by variations of the strength due to other causes than thickness.

It is altogether probable that in an extensive series of tests the strength would be found more nearly proportionate to the square of the thickness of the shell.

It has already been stated that theoretically the strength of tiles of the same diameter will be in proportion to the square of the thickness. With the same load the strength theoretically should be inversely proportional to the diameter for equal thickness. Neglecting the friction of the trench filling against the sides of the ditch, the load would be approximately proportional to the diameter. Putting these factors together, we would find some cause to believe that thickness of drain tile should be proportional to the

diameter of the pipe, for equal resistance to the pressures coming upon them.

Our experience in making this series of tests has convinced us of the very unsatisfactory character of the results made on samples of cement tile collected at random here and there around the state as a basis for scientific investigation. While such tests may be useful to get some idea of the character of the tile now being made, they may vary greatly owing to mistakes or carelessness in manufacture which cannot be made a matter of record. For example, in comparing the different proportions of sand and cement reported in one of the tables, we cannot be sure that the small portions of mortar out of which the individual tile happened to be made were really of the proportions indicated, nor can we be sure that the tile received the same treatment in curing.

Hence the only comparison between cement and clay drain tile which we feel warranted in making at this time is in the case of the cement tile manufactured by ourselves. A comparison of the tests of these tile with those of corresponding diameters of clay tile is here given.

COMPARATIVE AVERAGE STRENGTH OF CEMENT AND CLAY DRAIN TILE.

	Cement Tile.				Clay Tile.	
	Age 2 months.		Age 11 months.			
Internal diam., inches.	Thickness (inches)	Strength (lbs. per lin. in.)	Thickness (inches)	Strength (lbs. per lin. in.)	Thickness (inches)	Strength (lbs. per lin. in.)
24					2⅛	318
20	2¼	81				
20	1¾	69	1⅝	159		
18	2¼	128	2	307		
18	1¾	94	1½	222	1¼	200
15					1	103
12	2	137	2⅛	417	1⅛	158
12	1½	117	2½	200	⅞	141

A study of this table will convince any one that it is feasible to make cement drain tile which will attain all necessary strength and which will compare very favorably in this respect with clay tile.

Tests in Brooklyn.

The following tests of concrete pipe are given by Mr. Homer A. Reid in "Concrete and Reinforced Concrete Construction":

Size and description—	Thickness.	Breaking Weight.
12-inch round flat base	1$\frac{1}{16}$	10,624 lbs.
18-inch egg flat base	1⅝	*18,785 lbs.
18-inch egg flat base	1⅝	12,287 lbs.
18-inch egg flat base	1⅝	†13,190 lbs.
24-inch egg flat base	2	26,547 lbs.

In making these tests, a wooden beam 20 feet long was used, with a 2-foot fulcrum. The pressure was applied to a saddle hav-

*Cracked at 10,155 pounds; additional required to crush.

†Cracked at 9,717 pounds; additional required to crush.

ing a rubber gasket between it and the pipe, so as to give the saddle an even bearing and thus do away with any concentrated pressure.

Some clay pipe tests at the same time showed the following results:

Size and description—	Breaking Weight.
12-inch double-strength shale	7,756 lbs.
12-inch single strength vitrified	7,544 lbs.
12-inch standard Akron (average of 3)	5,500 lbs.
12-inch vitrified	7,859 lbs.
18-inch Akron double-strength	8,842 lbs.

Pipe Used on Irrigation Work.

For many years buried cement pipe has been used for the distribution of irrigating water in southern California. It is ordinarily considered safe for heads of water up to 14 feet, according to S. M. Woodward of the United States Department of Agriculture, who gives the following results of scattering tests:

Two lengths of 16-inch pipe, united with a cement joint three weeks old, did not break under a head of 20 feet, or 9 pounds per square inch. A 10-inch pipe broke under a head of 20 feet. An 8-inch pipe did not break under a head of 46 feet, or 20 pounds per square inch. A line one-half long of 10-inch pipe, specially made of a 1 to 2 mixture, carries constantly a head of 20 feet.

Reinforced Pipe at Pueblo, Colo.

More than 18,000 linear feet of hub and spigot concrete pipe, in 30 and 38-inch sizes, was made in connection with the development of a water system at Pueblo, Colo., as described in *The Engineering Record* for April 4, 1908. This pipe was all in 2-foot lengths, the shell of the 38-inch size being 3¼ inches, and that of the 30-inch size, 2½ inches thick. The concrete was made in the proportions of 1 part Iola Portland cement to 4½ or 5 parts of gravel obtained from the river, depending on the percentage of voids in the gravel. The latter was of excellent character for the purpose, varying from sand to stone that would pass a ¾-inch screen. The concrete was all mixed by hand, and was thoroughly hand-tamped in the molds in which the pipes were cast. The resulting pipe was of excellent quality, as was determined by a number of tests made shortly after the manufacture of the pipe was commenced.

Each section tested was first placed in a hole and imbedded, nearly up to the springing line, in sand. A platform, supported by four saddles made of 1½-inch oak, and equally spaced on the

section, so as to fit closely across the top of the pipe, from springing line to springing line, was then loaded with cement in sacks until the pipe failed, or at least showed signs of failure, since it was impossible to destroy some sections with the loads available. After the first two sections had been tested in this manner it was evident that the saddles fitted so closely at the springing lines that the pipe in crushing had no opportunity to spread at these points, a condition which would scarcely have obtained in actual service. The under edges of the saddles were, therefore, cut away until they did not rest on the pipe for about 4 inches above the springing line on each side. About twenty plain and reinforced sections were then tested to determine their safe and ultimate carrying capacities. The pipe, when tested, was from 15 to 26 days old. Rings of round ⅜-inch iron rods, barbed wire, and annealed round wire were used in the reinforced sections tested. The ⅜-inch rods gave the best results, but were too expensive for the purpose. The annealed round wire produced better results than the barbed wire, and as the pipe reinforced with the round wire had sufficient strength, this wire was accordingly used in all of the pipe that was reinforced. The results of the tests were fairly uniform, and demonstrated that pipe reinforced with seven No. 5 wires in each 2-foot section could safely be used in the trenches over 12 feet deep; and that plain pipe had ample strength for the balance of the work. The section of the flow line in which concrete pipe was used is also built of plain pipe, the maximum head on this section being 7 feet. This section of the line has been perfectly satisfactory in service.

German Tests.

The following summary of results is taken from a detailed report of results of a test of clay and cement pipe made in 1907 by Burchartz and Stock, of the Royal German Building Material Testing Department:

Inside diam., inches.	Thickness of Shell, Inches.		Resistance Against External Pressure, Pounds,		Resistance Against Internal Pressure, Atmospheres,	
	Clay.	Cement.	Clay.	Cement.	Clay.	Cement.
8	0.92	1.40	4,330	4,550	17.9	8.8
12	1.04	1.92	5,960	9,510	11.9	2.3
16	1.12	2.16	7,280	8,120	9.6	...
18	1.28	2.24	4,510	8,050	9.3	...
20	1.44	2.44	7,720	6,750	10.6	2.9
24	1.72	2.80	6,490	7,960	7.2	...
28	1.88	3.20	7,210	10,120	8.7	2.7
32	1.96	3.40	7,000	7,170	7.7	...

Tests for Loss of Cement in Solution.

A few tests to ascertain the loss in weight of drain tile through the solution of its cement bond are described by Mr. A. O. Anderson of Lake City, Iowa, in *Engineering-Contracting* for December 9, 1908. For the purpose of this test, specimens from drain tile of various ages were thoroughly dried, brushed with a stiff bristle brush to remove all loose particles, weighed, and then placed in boiling water which was changed at intervals of one hour during the test. After being boiled for different periods, the specimens were dried, weighed and then replaced in water again for a longer interval of time. As the test pieces were subjected to the mechanical as well as the chemical action of boiling water, a loss from abrasion as well as from solution may occur. Results from two different series of tests are herewith given:

Series I.

No.	Original Dry Weight.	Weight after boiling 1 hour.	Weight after boiling 7 hrs.
16	75.450 g.	74.780 g.	75.260 g.
24	53.520 g.	53.112 g.	53.305 g.

No. 16 is from a 16-inch cement tile; age about 60 days; mixture 1 to 3½, new.

No. 24 is from 24-inch cement tile; age about 2 years; mixture 1 to 4. This tile has laid along line of ditch for about two years.

Series II.

No.	Original Dry Weight.	Weight after boiling 1 hour.	Weight after boiling 5 hrs.	Weight after boiling 15 hrs.
A2	27.800 g.	27.604 g.	27.865 g.	27.860 g.
A3	23.422	23.480	23.520	23.688
A5	28.605	28.516	28.685	28.955
A7	33.815	33.855	33.997	34.030

A2 and A3 are from 20-inch and A5 and A7 from 18-inch cement drain which have been installed about four years.

An examination of these results will show that at the end of the first hour's boil, the decrease, if any, occurs, and upon further boiling the weight actually increases.

Mr. Anderson considers the loss in weight due to the fact that the cement has a certain amount of gypsum or other soluble substance mixed with it, which, with the free lime which the cement may contain, will be lost during the early stages of boiling. As the tile from which the specimens in Series I were taken are comparatively new and had not been subject to the action of percolating water, a larger decrease in weight is obtained than from those used in Series II, which have been used for drainage purposes for

several years and probably had lost the greater part of their soluble components.

The increase in weight which is secured upon prolonged boiling may be due to the variation in size of grains in Portland cement. The rapidity of chemical action is dependent upon temperature and size of grain, the time and moisture being constant. "As but half of 'market' cement is supposed to be ground fine enough to possess setting qualities under normal conditions," says Mr. Anderson, "the remainder will probably hydrate if kept in contact with moisture for a sufficient length of time or if subjected to a high temperature for a shorter interval of time. The specimens being subjected to the hot water, it is probable that many particles hydrated which because of their size are not able to take up water and set under normal conditions."

Experiments in Arizona.

As a result of work done at the Arizona Experiment Station, G. E. P. Smith of that institution says that cement pipe for small irrigating ditches is from every point of view to be recommended.

With a view to determining the best mixtures and the cost of cement pipe in the Santa Cruz valley, a molding outfit was secured and some experimental pipes were made. The size selected was of 15 inches diameter, and several lots of pipe were made of a mixture of 1 part cement to 3½ parts unscreened arroyo sand. There were ten 2-foot lengths, each hard and strong, of perfect shape and representing a cost of only 38½ cents per lineal foot. The amount of cement used was five sacks.

The fourth lot was made of a very lean mixture of cement, lime paste and sand. The replacement of a part of the cement by lime was made for the double purpose of reducing the cost and obtaining a denser and more impermeable pipe. The paste was thinned to a consistency that permitted it to mix thoroughly with the sand, and the bell ends were made of a mixture of 1 part of cement to 3 parts of sand. The results were very satisfactory.

The fifth and sixth lots were made in another locality, and the sand and gravel were of a different character from those used previously, so that screening was necessary. All above one-half inch in size was rejected.

There is a difference of opinion, says Mr. Smith, in regard to the shape of the small tile and the kind of a mold to be used. In California the bevel and tongue joint is used. It is quickly molded and quickly laid. The bell and spigot joint is liable to suffer injury to the bells, but will probably be laid with tighter joints than the beveled end pipe, especially by an inexperienced person.

CHAPTER VI.

Methods and Cost of Manufacture.

As a customary thing cement tile can be sold at the same prices as clay tile and show a somewhat larger margin of profit. The prices of clay tile are usually allowed to make the price of cement tile, however. Very few manufacturers think it advisable to cut under the price. In fact, there is no reason why it should be done. A lower price would tend to give the public an idea that cement tile was inferior to the clay product. Of course, on a competitive bid, a manufacturer will have to be governed by circumstances and will naturally make a price to secure the order.

Of course many cost figures such as I have given represent only the most tangible things which one can lay his hands on. There are the matters of idle days, and culls, and unsold tile, and interest on investment, and repairs, and superintendence, and all those things which a man is prone to forget in figuring out what his tile costs him.

On the other hand, however, there must be taken into consideration the fact that the industry is new, that many plants are not working under the most favorable or economical conditions, and that in probably very few if any cases has the limit of productiveness of equipment or men been reached or the most economical methods been worked out.

The cost and methods of manufacture can perhaps best be arrived at by giving actual figures furnished by several manufacturers as well as detailed descriptions of a number of different plants, showing something of their layout, equipment, and the various items making up their running expense account.

Indiana Man's Experience.

A manufacturer of cement tile in Indiana, using a Schenk machine, furnishes the following data of runs on 5 and 6-inch tile, the proportions varying from 1:4½ to 1:5:

1908.								
June	15—	3,000	5-inch	tile;	used	51	sacks	cement
"	22—	3,000	5	"	"	52	"	"
"	23—	3,000	5	"	"	48	"	"

June	27— 3,200	5-inch	tile;	used	52	sacks	cement
July	1— 3,350	5	"	"	54	"	"
"	2— 3,400	5	"	"	54	"	"
"	3— 2,900	5	"	"	42	"	"
"	6— 3,000	5	"	"	46	"	"
"	7— 3,000	5	"	"	42	"	"
"	31— 3,200	5	"	"	47	"	"
Aug.	1— 2,660	5	"	"	38	"	"
Sept	9— 3,150	5	"	"	48	"	"
12 days,	36,860	5	"	"	574	"	"

And the labor of—

1 pit man, per day	$ 1.50
1 mixer, per day	1.75
1 boot man, per day	1.75
1 machinist, per day	1.75
1 stripper, per day	1.75
2 yard men @ $1.50 per day	3.00
3 offbearers @ $1.00 per day	3.00
12 gallons gasoline	1.26
	$15.76

Labor and gasoline 12 days @ $15.76 per day	$189.12
574 sacks of cement @ $1.25 per bbl	179.37
90 yards of gravel @ 40c per yard	36.00
Total	$404.49

Making an allowance of 3 per cent for breakage, this makes a cost of $11.31 per 1,000.

On 6-inch tile the figures furnished by the company are as follows:

1908.							
April	13— 2,300	6-inch	tile;	used	56	sacks	cement
"	14— 2,300	6	"	"	55	"	"
"	16— 2,600	6	"	"	66	"	"
May	1— 2,500	6	"	"	49	"	"
July	8— 3,300	6	"	"	57	"	"
"	14— 2,900	6	"	"	59	"	"
"	15— 3,000	6	"	"	55	"	"
"	28— 2,900	6	"	"	60	"	"
Aug.	14— 2,600	6	"	"	52	"	"
"	31— 2,700	6	"	"	51	"	"
Sept.	12— 3,100	6	"	"	54	"	"
"	16— 2,948	6	"	"	50	"	"
12 days,	33,148	6	"	"	664	"	"

And the labor of—

1 pit man @ $1.50 per day	$ 1.50
1 mixer man @ $1.75 per day	1.75
1 boot man @ $1.75 per day	1.75
1 stripper @ $1.75 per day	1.75
2 yard men @ $1.50 per day	3.00
3 offbearers @ $1.00 per day	3.00
Total labor for one day	$14.50

Labor cost for twelve days' run @ $14.50	$174.00
664 sacks cement @ $1.25 per bbl	207.50
144 gallons gasoline @ 10½c	15.12
100 yards sand and gravel @ 40c	40.00
Total	$436.62

Again allowing 3 per cent for breakage, the figures show this size to cost $13.23 per 1,000.

A Plant in Detail.

One of the first plants visited was that of one of the pioneers in the business in an Iowa town. He had two plants, one of which makes the smaller sizes and the other the larger sizes. The process of manufacture pursued at the two plants is entirely different, so that they will be taken up separately. Both plants are housed in buildings put up of concrete blocks by the manufacturer's own men, this being also one of the branches of the industry pursued by this enterprising manufacturer.

The plant for the smaller sizes occupies a building 90x100 feet. It is equipped with a Schenck drain tile machine and a Eureka mixer operated by a Fairbanks-Morse gasoline engine. The factory runs 10 hours a day and turns out 3,500 tile per day of the 4 to 6 inch sizes, and from 2,000 to 2,300 of sizes up from that to 12 inches. To accomplish this the following labor cost is required:

1 man hauling sand	$ 3.50
7 men at factory at $1.75	12.25
2 men and teams hauling away	7.00
	$22.75

Sand is secured from a river bed near by. It is pumped out with a centrifugal pump and banked up, costing about 10 cents per yard at the bank. It is an unusually sharp, clean

Cost of Cement Pipe and Tile.

The following table is given by the Miracle Pressed Stone Company of Minneapolis. It is figured on a basis of a 1:3 mixture, with sand at 75 cents per yard, cement at $2.00 per barrel, and labor at $2.00 per day. The 4 to 8-inch sections are considered as 18 inches long, and 10 to 36-inch sections as 2 feet long.

Kind of Tile.	Thickness	Cubic Ft. Sand.	Cost of Sand.	Cost of Cement.	Cost of Labor.	Cost of Pipe.	Cost per Foot
4-inch Bell-end	¾ inch	.079	**.004**	.011	.06	**.077**	**.05**
4-inch Straight	¾ inch	.0633	.002	.01	.04	.044	.028
5-inch Bell	1 inch	.232	.006	.013	.062	.081	.054
5-inch Straight	1 inch	.1964	.005	.011	.055	.071	.047
6-inch Bell	1 inch	.354	.01	.015	.08	.105	.07
6-inch Straight	1 inch	.324	.007	.012	.058	.077	.05
8-inch Bell	1 inch	.452	.015	.035	.08	.13	.086
8-inch Straight	1 inch	.432	.01	.03	.06	.10	.066
9-inch Bell	1⅜ inch	.695	.0194	.083	.09	.1924	.0962
9-inch Straight	1⅜ inch	.622	.0174	.074	.0655	.1569	.0785
10-inch Bell	1⅜ inch	.83	.025	.105	.10	.23	.115
10-inch Straight	1⅜ inch	.68	.02	.085	.07	.175	.087
12-inch Bell	1½ inch	1.1	.03	.18	.10	.31	.155
12-inch Straight	1½ inch	.88	.025	.145	.07	.24	.12
15-inch Bell	1⅝ inch	1.4	.039	.235	.11	.384	.192
15-inch Straight	1⅝ inch	1.17	.033	.195	.08	.308	.154
16-inch Bell	1⅝ inch	1.42	.04	.25	.12	.41	.205
16-inch Straight	1⅝ inch	1.24	.035	.215	.085	.325	.162
18-inch Bell	1¾ inch	1.84	.055	.28	.13	.465	.237
18-inch Straight	1¾ inch	1.5	.045	.21	.09	.345	.172
20-inch Bell	1¾ inch	1.95	.056	.325	.13	.511	.255
20-inch Straight	1¾ inch	1.67	.045	.266	.10	.411	.205
24-inch Bell	2 inch	2.75	.075	.46	.15	.685	.343
24-inch Straight	2 inch	2.25	.063	.37	.12	.553	.276
26-inch Bell	2 inch	3.05	.09	.52	.16	.77	.385
26-inch Straight	2 inch	2.5	.075	.43	.125	.63	.315
30-inch Bell	2½ inch	3.70	.101	.615	.17	.886	.443
30-inch Straight	2½ inch	3.13	.086	.55	.15	.786	.393
36-inch Bell	3 inch	4.90	.134	.815	.20	1.149	.575
36-inch Straight	3 inch	4.32	118	.72	.17	1.008	.51

grade of sand, admirably suited for the purpose of making concrete tile.

Water is bought from the city at the rate of 11 cents for 1,000 gallons, and the bill averages about $1.00 per day. Gasoline costs about 75 cents per day.

For the most part the tile is made in the proportion of 1 to 4. The office records show that with a 1:4 mix:

1 yard of sand will make 340 tile 4 inches in diameter
1 yard of sand will make 275 tile 5 inches in diameter
1 yard of sand will make 240 tile 6 inches in diameter
1 yard of sand will make 175 tile 7 inches in diameter
1 yard of sand will make 150 tile 8 inches in diameter
1 yard of sand will make 90 tile 10 inches in diameter
1 yard of sand will make 65 tile 12 inches in diameter

For each yard of sand on a 1:4 mix approximately 6¾ sacks of cement will be used.

With an average output of, say, 3,400 per day of the 4-inch tile, 10 yards of sand will be used and 17 barrels of cement. The cost can therefore be figured out as follows:

Labor cost as above	$22.75
10 yards sand (at pit)	1.00
Water	1.00
17 barrels cement, at $1.50	25.50
Gasoline	.75
	$51.00

This works out to a cost of $15.00 per 1,000 feet.

The tile are carried from the machine to racks of six tiers each with five lifts to each tier. Each rack will thus hold 300 tile of 6 inches diameter. Some of these racks are shown in one of the illustrations. The room is sufficient to hold the output of one week.

The tile are never allowed to dry for the first six days. The time of the first sprinkling and the frequency of sprinkling thereafter depend entirely upon weather conditions. During hot, dry seasons in summer, they may need to be wet down as soon as 2 hours after being taken from the mold; after that they will require sprinkling two or three times a day. At the end of the six days they are allowed to remain in the sheds for a day or two, protected at all times from drafts, and are then carted to the drying yards, where they complete the process of curing, which in no case is allowed to occupy less than 30 days. If the weather is hot and dry they are sprinkled occasionally in the yard.

The plant which makes the larger sizes occupies a con-

PRICES PER 1,000 FEET AT WHICH CEMENT TILE ARE SOLD AT DIFFERENT POINTS.

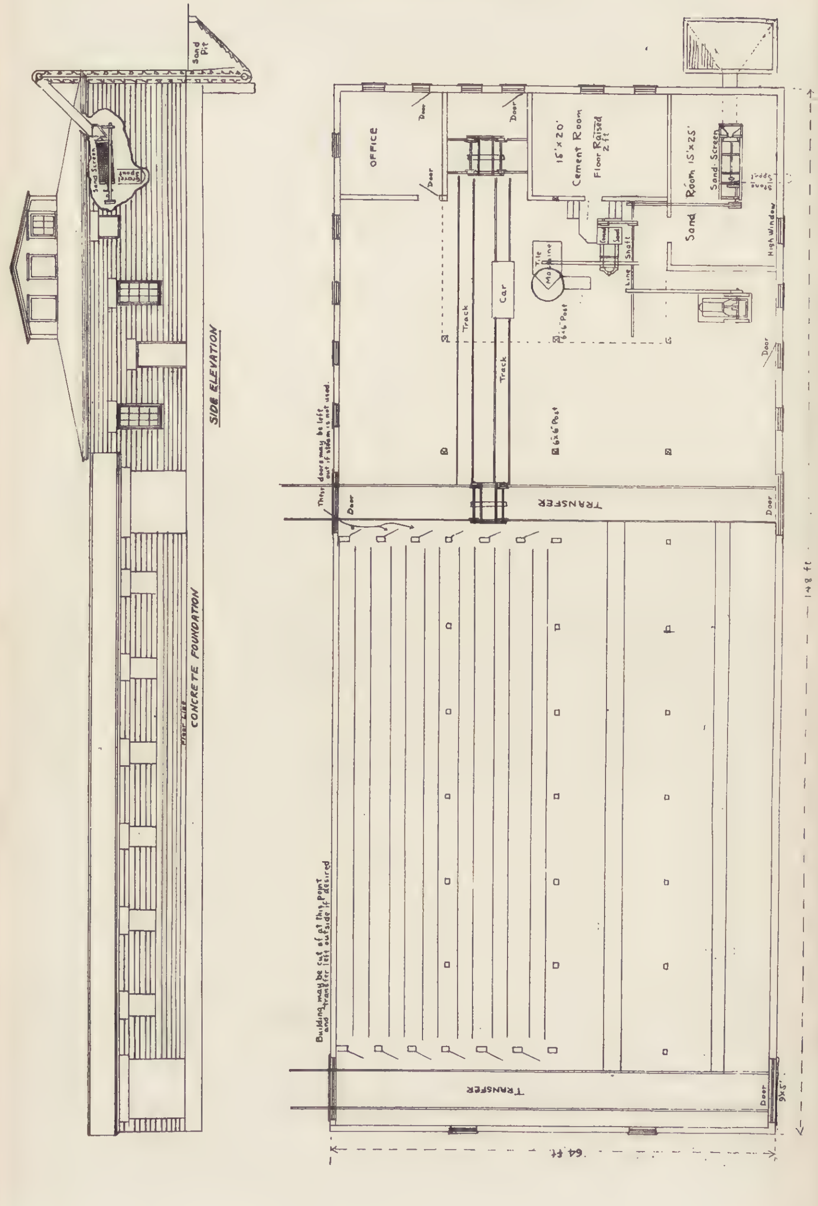
Diameter.	Colorado.	California.	—Three points in Iowa.—			Illinois.	Wisconsin.	Florida.	Indiana.
4-inch	$ 40.00	....	....	$ 20.00	$ 15.00	$ 16.00	$29.00	....	$ 18.00
5-inch	45.00	....	$ 23.50	25.00	20.00	18.00	....	$50.00	22.00
6-inch	50.00	$ 90.00	30.00	32.00	30.00	28.00	40.00	....	33.00
7-inch	....	....	40.00	42.00	40.00	35.00	....	....	42.00
8-inch	80.00	120.00	50.00	52.00	50.00	45.00	....	....	50.00
10-inch	110.00	180.00	85.00	84.00	85.00	65.00	....	....	65.00
12-inch	140.00	240.00	105.00	105.00	100.00	85.00	....	....	90.00
14-inch	....	....	175.00	175.00	....	150.00	....	....	140.00
16-inch	....	400.00	250.00	225.00	....	190.00	....	....	200.00
18-inch	....	500.00	350.00	325.00	....	238.00	....	....	250.00
20-inch	....	....	450.00	425.00	....	275.00	....	....	300.00
22-inch	....	....	550.00	500.00	....	350.00	....	....	....
24-inch	....	....	650.00	600.00	....	400.00	....	....	400.00

crete block building 50x130. It has a perfectly level concrete floor throughout, doing away with the necessity of pallets, as the tile are made directly on the floor where they are to remain for curing, a square of heavy wrapping paper being placed under each, merely to prevent the tile adhering to the floor.

This plant is equipped for working throughout the winter, being provided with 1.000 feet of steam radiation, with provision whereby this can be increased on short notice should the temperature go to a point where this would prove insufficient. Steam for heating, as well as for operating the mixer, is furnished by a 10-horse power Aultman traction engine, which answers all purposes at a steam pressure of 30 pounds, burning only about 1½ tons of coal per week. The mixer used is a Scheiffler proportioning mixer, made by the Hartwick Machinery Company, of Jackson, Mich., and the tile are made in Miracle molds, manufactured by the Miracle Pressed Stone Company, of Minneapolis.

PLANT FOR MAKING LARGE SIZES OF TILE.

At the time of the writer's visit the crew was working on 24-inch tile, which it was stated is in such great demand that he can scarcely make it fast enough. Two molds are kept going, with two men at each mold. Each mold also requires a wheelbarrow man to deliver concrete and shovel it in. Added to these are a man in the sand bin, a man who runs the mixer and sprinkles the finished tile, and a young man who



LAYOUT OF CEMENT TILE PLANT AS DESIGNED BY J. H. STEWART, WATERLOO, IOWA.

is engineer and general handy man. There is also, as before, the man and team hauling sand. These, in a day of 8 hours, make 100 of these 24-inch tile. Each tile consumes a trifle more than one sack of cement and 3 cubic feet of sand, and weighs approximately 300 pounds.

The cost may be worked out as follows:

1 man and team hauling sand	$ 3.50
9 men at $1.60	14.40
26 barrels cement at $1.40	36.40
12 yards of sand (cost at pit)	1.20
Fuel and incidentals	2.00
	$57.50

For 100 tile per day this would make a cost per tile of 57½ cents.

The same methods and conditions govern the curing of this as of the smaller tile.

Another Similar Plant.

A similar plant to the above was visited in another part of the state, its identity being withheld by request.

The factory is divided into two departments—one for the small and one for the large tile. The former is 50x100 feet, equipped with a Schenck tile machine, Snell mixer, and 14-horsepower gasoline engine. The tile are carried from the machines to a series of shelving, and allowed to cure there four to seven days, depending on the capacity of the plant. After being taken to the yard they are usually sprinkled three or four days, the amount of water depending on the atmospheric conditions.

The best run ever made at the factory was 5,070 of the 5-inch size. But this was a phenomenal run, far ahead of the average. The output as a general thing runs about as follows:

12 inches diameter, 2,000 to 2,200 per day.
10 inches diameter, 2,200 to 2,500 per day.
8 inches diameter, 2,500 to 2,800 per day.
7, 6 and 5 inches diameter, 3,000 to 3,500 per day.

On sizes up to and including 8-inch the following are required:

1 man and team hauling sand	$ 3.50
1 man screening	1.75
1 man mixing	2.00
1 man feeding the machine	1.50
1 man running the machine	2.50
4 men carrying away	8.00
2 men wheeling to yard	3.50

Half time of boy sprinkling	$0.50
Half time of foreman	2.50
Half time of yard man	1.00
2,000 gallons of water	.36
9 gallons of gasoline	1.04
	$28.15

With a product of 2,600 8-inch tile per day, the above items would enter into the cost to the extent of $10.83 per 1,000. For 1,000 of this size, 7 yards of sand will be required, which amounts to 70 cents at the pit, the cost of hauling being included in the above table. Adding to this $18.00, the cost of 12 barrels of cement required, we have a total cost on 8-inch tile of $29.53 per 1,000.

When the plant is running on 10 and 12-inch tile, an extra man is required on the mixer and two extra men on the ma-

THE CURING SHELVES.

chine, as well as additional yard and teaming help, making an additional cost of $9.20. Adding this to the $28.15 above, we have $37.35. Assuming the average daily output of 10-inch tile to be 2,500, which would require 30 yards of sand and 50 barrels of cement, the cost would be as follows:

Labor, etc.	$ 37.35
Sand	3.00
Cement	75.00
	$115.35

This would be a cost per 1,000 feet of $46.14.

The larger sizes are made in Miracle molds, the plant for this part of the work occupying a room 30x100 feet. The mixing is done by hand, three men mixing their own batch and molding. Dividing their time equally among 14, 18 and 24-inch tile, they will average from 80 to 90 tile per day. The cost will run about as follows:

1 man and team hauling sand	$ 3.50
3 men at $2.00	6.00
1 man delivering to yard	1.75
Half time of foreman	2.50
Half time of yard man	1.25
Half time of water boy	.50
2,000 gallons water	.36
	$15.86

Water is bought from the city hydrant. The tile is given practically the same subsequent treatment as the smaller sizes.

The small tile are made with a 1:4 mix, and the larger sizes 1:3.

Another plant in Iowa gives the following figures for 1,000 tile, based on a 1:4 mixture, though the prices of sand per yard, cement per barrel, and labor per day, are not given:

	Cost per 1,000				Selling
Size.	Sand.	Cement.	Labor.	Tot. Cost.	Price.
4-inch	$1.25	$ 4.00	$4.25	$ 9.50	$ 21.00
5-inch	1.85	4.90	4.25	11.00	25.00
6-inch	2.60	8.75	4.25	15.60	34.00
8-inch	4.10	12.25	4.25	20.60	54.00
10-inch	5.25	17.50	7.00	39.75	90.00
12-inch	8.25	35.00	7.00	50.25	110.00

Still another manufacturer gives the following figures for 1,000 tile, based on a 1:4 mixture, with cement at $1.20 per barrel and sand at 25 cents per load.

	Weight	Cost per 1,000				Selling
Size.	Per 1,000.	Cement.	Sand.	Labor.	Tot. Cost.	Price.
4-inch	6,250	$ 3.10	$0.60	$ 7.50	$11.20	$16.00
5-inch	8,500	4.25	.75	7.50	12.50	20.00
6-inch	11,000	5.50	.85	7.50	13.85	25.00
7-inch	14,500	7.25	1.25	10.00	19.50	35.00
8-inch	18,500	9.25	1.75	15.00	26.00	45.00
10-inch	25,000	12.50	2.30	20.00	34.80	65.00
12-inch	35,000	17.50	3.30	30.00	50.80	95.00

Tile Carried Away by Belt Conveyors.

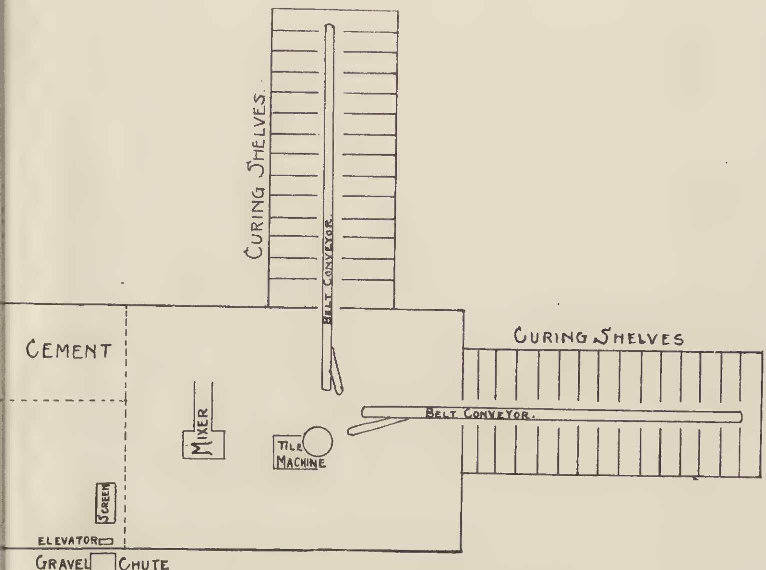
The piece of equipment of special interest at the plant of the Independence Cement Tile Company, Independence, Iowa, is the belt conveyor which carries the tile from the tile ma-

TILE CARRIED AWAY BY BELT CONVEYORS.

chine back to the shelves. Two of these conveyors are installed, running in two directions from the tile machine, as shown in the diagram.

The curing shelves are placed in two wings to the main

building. One of the belt conveyors runs back to the end of each one of these wings, occupying the larger part of a central alley, with sufficient room on each side for a man to walk through conveniently. These conveyors are very simple affairs, the two outfits costing not over $150. The belt itself is a 12-inch canvas belt running over wooden rollers of about 4 inches in diameter, placed 4 feet apart. The belt runs between guides. These guides are made of dressed lumber and must be made fairly smooth, without any projecting edges or



LAYOUT OF PLANT AT INDEPENDENCE, IOWA.

corners, in order that the molds, as they pass along, may not be caught and the tile which they carry be destroyed.

The jackets containing the tile are placed on the upper belt from the machine and are carried along until taken off by men stationed along the belt in the alleys. The empty jackets are then placed on the belt down below and returned to the main workroom, where a shunt is provided for them, as shown in the diagram. One of these conveyors is well shown in the illustration.

The only objection which has been found to the conveyor is that the wave motion of the belt passing over the rollers has been found to occasionally damage a tile. In this particular case, this objection has been obviated by placing a strip of steel on the rollers under the belt. If made without sharp projections, this strip of steel will not materially increase the wear on the belt and will do away entirely with breakage from the cause mentioned. Of course, a troughed belt conveyor could be installed which would do away with the up-and-down motion of the belt and would also avoid any possibility of the jackets striking the guides and shattering tile. Such a conveyor would, however, cost much more.

This conveyor is used only on sizes up to and including 6-inch.

In addition to the conveyor, above described, this plant is equipped with a Schenk tile machine, Perfection mixer, screen, 20 horsepower steam engine, gasoline engine for summer use, and an ordinary pump operated by the engine. The output of the plant for a day of ten hours runs about as follows:

4-inch	3,500 to 4,000
5-inch	3,200 to 3,500
6-inch	3,000
12-inch	860

Sand is bought, delivered, at 60 cents per yard. The follow ing is the labor cost required at the plant:

1 foreman	$ 3.00
1 engineer	2.00
1 man running tile machine	2.00
1 man at the mixer	1.50
1 man removing tile	1.50
3 skinners, $1.50 each	4.50
1 man looking after sand elevator and screen and sprinkling tile	1.50
2 men in the yard with 1 horse each, $2.50 each	5.00
	$21.00

Assuming that 3,000 6-inch tile (the output of one day) require 13 yards of sand and 22 barrels of cement, we have the following costs:

Labor as above	$21.00
13 yards sand at $0.60	7.80
22 barrels of cement at $1.50	33.00
	$61.80

This is a cost of $20.60 for 1,000 tile.

A Completely Equipped Plant.

One of the most elaborately equipped plants to be found anywhere is that of the Armstrong Cement Works, Armstrong, Iowa. It occupies a building, 72x149 feet, with outer walls of Anchor concrete blocks and a concrete floor throughout.

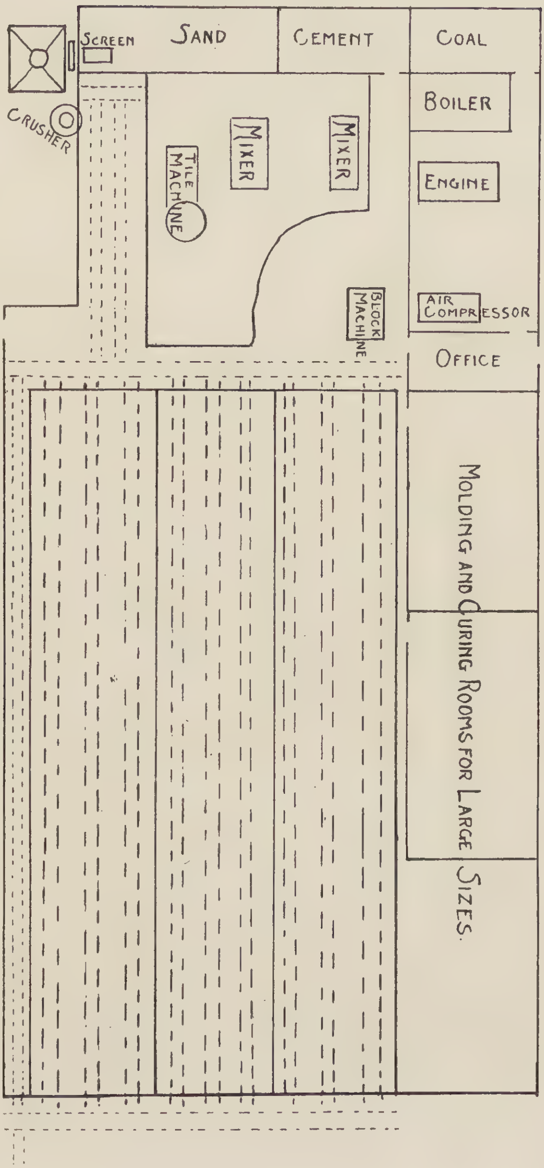
The plant is equipped for steam curing, this method being used entirely. For the purpose of curing the machine-made tile, three curing rooms are provided, each 14½x94 feet, and each equipped with three tracks. These tracks connect with transfer tracks at each end. One of these is between the curing rooms and the tile machine and connecting with the tracks alongside the machine; the other is outside the building and connects with the track to the storage yard.

Three rooms for the making and curing of hand-made tile are also provided with 900 feet of floor space, as well as the room where the tile machine and mixers are located, engine room, coal room, cement and sand storage and office.

The company has given me the following inventory of their plant, with permission to use it. It will be of interest as showing the make-up and cost of a fully equipped plant:

Building	$6,000
Grounds	500
Track system, with Chase cars 8 feet x 40 inches, three decks to cars	2,500
Lake City tile machine	1,500
Two Lake City continuous mixers	500
6x6 Chicago pneumatic air compressor, with Keller rammer, pipe and hose	325
Universal Stone Crusher No. 2	500
Anchor block machine, with pallets	350
Lake City and Miracle molds	300
Electric lights (dynamo, etc.)	235
Sand elevator	110
Screen	50
Belt conveyor for sand	100
Engine and boiler (30-horsepower Erie)	600
Piping	200
Sundry equipment	200
	$13,970

For an exclusive tile factory there could of course be deducted from this the $350 for block machine and pallets. The same number of men would still be employed, the only difference being that the men employed on large sizes of pipe would devote all their time



LAYOUT OF PLANT AT ARMSTRONG, IOWA.

to that work, instead of putting in part time making blocks. The working force is as follows:

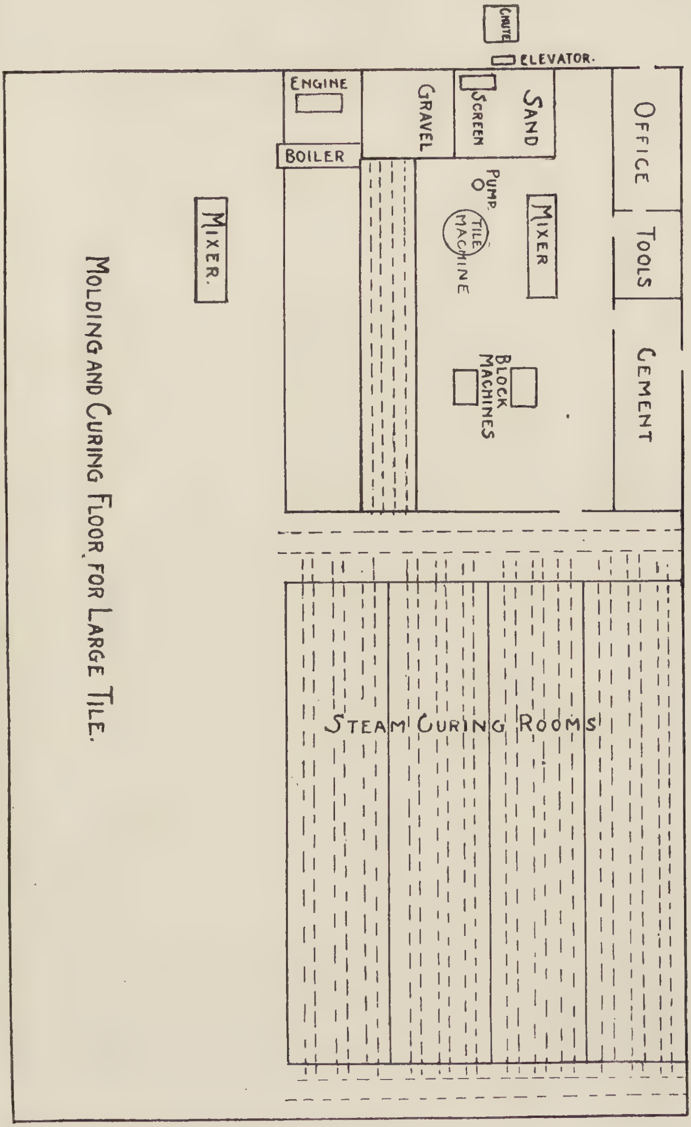
1 manager.
1 foreman.
6 men with teams.
1 engineer and fireman.
1 man handling gravel.
2 men making large tile (or blocks).
6 men on tile machine and mixer.
1 man unloading cars.
3 men outside.
1 boy sprinkling, etc.

The two men who handle the large sizes work independently, mixing their own "mud," and molding. At the time of my visit they were working on 22-inch pipe, and were turning out 60 per day. They were using a mix with somewhat more water than many manufacturers would suppose to be possible, and were getting exceptionally good results. In addition to the large amount of water in the mix, a small amount of water is sprinkled on the top of the pipe before the shell is removed. This gives the pipe a smooth edge, and supplies an added amount of moisture at the point which has a tendency to dry out first. Any sticking to the forms which might result from the excess of moisture is obviated by running a small trowel around between the pipe and the shell as soon as the latter is unclamped.

These large pipe are tamped with a Keller pneumatic rammer, air for which is supplied by a 6x6 air compressor made by the Chicago Pneumatic Tool Company. The same outfit is also used in tamping blocks.

Sand is secured about a half mile away, at 20 cents per yard at the pit. When brought up it is dumped into a hopper outside the building, from which it is taken by a conveyor to the screen, the sand being then either delivered to the mixers or to the sand bin, at the pleasure of the operator. The coarse parts which are screened out go to the crusher and are brought down to usable size.

All sizes of pipe and tile are sprinkled the next morning after manufacture. The curing is then completed by steam. The small tile are left on the cars in the curing room, just as they come from the machine. A steam pipe runs almost the full length of each of the long curing rooms, open at the end and with openings down its length at intervals of about 24 feet. This pipe was originally located near the roof, but was changed to a position



LAYOUT OF PLANT AT WEBSTER CITY, IOWA.

INTERIOR OF PLANT AT WEBSTER CITY, IOWA.

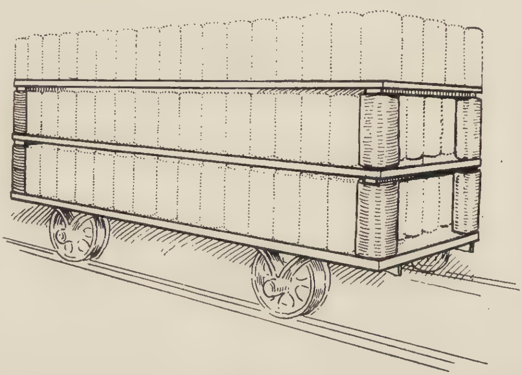
along the floor, the idea being that this would give a better distribution of steam, although this suppostion has not been definitely established. Each of the smaller curing rooms for larger tile has an open-end pipe extending into it near the floor. The exhaust from the engine is amply sufficient to keep the rooms very moist. The plant uses 1,200 to 1,500 pounds of coal per day.

At Webster City, Iowa.

At the plant of the Cement Pipe & Tile Company, Webster City, Iowa, a combination of steam and water curing is insisted upon as the most successful process. This plant is well laid out and fully equipped, the layout being shown in the accompanying diagram. The building is 82x140 feet. The diagram very largely explains itself. The equipment of the plant is as follows:

1 Schenk tile machine.
2 Perfection mixers.
2 Anchor block machines.
30-h. p. boiler.
12-h. p. gasoline engine.
Sand screen.
Elevator.
Pump, etc.

The boiler is used for curing, also for heat radiation in cold weather. A temperature of 40° or above is maintained.



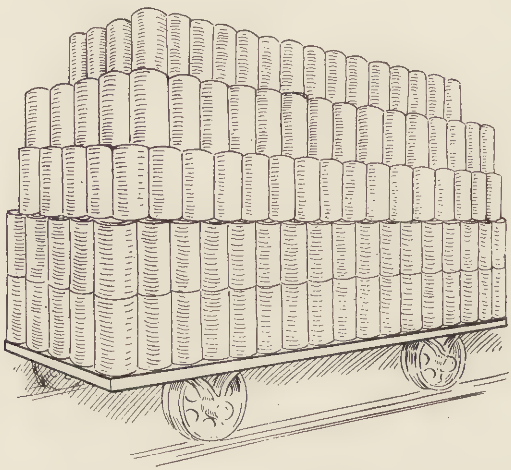
CAR AS IT GOES FROM THE MACHINE INTO THE CURING ROOM—THE DECKS REST ON CURED TILE.

There are three steam curing rooms, with five tracks each. Over each track runs a water pipe, with sprinkler heads placed at intervals of 4 feet. This allows two sprinkler heads over each

8-foot car. In addition to this water equipment, a steam pipe is carried along one end of the curing rooms with an opening into each room. This steam pipe is also connected with the water pipe in such a way that should the steam be too dry, water can be turned into it.

Cars 8 feet long and 38 inches wide are used, together with additional decks of the same size. The method of handling is somewhat unusual, and is as follows:

The car proper is filled with tile from the machine, with a cured tile placed at each corner. A deck is then placed on top, the cleats resting on the four cured tile at the corners. This deck is again filled, four cured tile being placed at the corners as before, and another deck placed on top. When this deck is filled, the car is taken into the curing room.



CARS AT WEBSTER CITY PLANT AS RELOADED NEXT DAY.

In order to economize space, the cars are reloaded the next day, the decks being taken out and the tile placed on the cars in approximately pyramidal form. In this way the load of three cars can be placed on two, thus saving space, allowing cars to be released, and doing away with the necessity of having so many decks. This arrangement also allows the tile to be wet more thoroughly.

With the cars thus placed on the tracks in the curing room, valves are turned on which control the pipes over the tracks where

the loaded cars are standing, and they are sprinkled from the sprinkler heads. This rapid method of sprinkling will, it is thought, more than make up for the time required in reloading the cars.

This plant employs a force of about ten men, with a foreman at $3.50, machine men at $2.50 and laborers at $1.75.

Rotten Period.

It has been noted by some manufacturers of cement tile that the tile has what they have termed "a rotten period," during which time it is much more susceptible of breakage than earlier or later. This period occurs from about the eighth to the twentieth day, so that tile only three or four davs old is found very often to be much stronger than it is during this period. After this time it again begins to gain strength, increasing in resisting powers until its ultimate strength is reached. The explanation of this phenomenon is supposed to be as follows: The tile is usually kept moist during the first seven days, during which time the process of crystallization goes on quite rapidly, giving the tile increased strength from day to day. After the seven days, tile is taken into the yard where it dries out very rapidly. Crystallization is therefore retarded and the tile loses in strength. After a week or ten days it begins to draw moisture from the atmosphere and the process of crvstallization again goes forward more rapidly.

Figures on Materials Required.

The following figures are given by the Cement Tile Machinery Company, Waterloo, Iowa, as being the result of actual tests made by manufacturers, with a 1:4 mix:

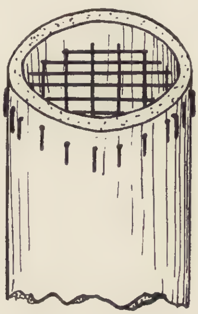
2¼ bbls. cement	1¾ yards sand	Make 1,000	4-inch tile
3 bbls. cement	2½ yards sand	Make 1,000	5-inch tile
5 bbls. cement	3½ yards sand	Make 1,000	6-inch tile
6 bbls. cement	4½ yards sand	Make 1,000	7-inch tile
7 bbls. cement	5½ yards sand	Make 1,000	8-inch tile
10 bbls. cement	7 yards sand	Make 1,000	10-inch tile
16¾ bbls. cement	11 yards sand	Make 1,000	12-inch tile

The same company also gives the following cost table for making tile by hand with "Easy" molds. These are made in 2-foot lengths, and the figures are based on a 1:4 mixture, with sand at $1.00 per yard, cement at $2.00 per barrel. and labor at $2.00 per day:

Size of Tile.	Cost Sand.	Cost Cement.	Cost Labor.	Cost Per Foot.	Days work for 3 men.
12-inch	$0.02	$0.12	$0.06	$0.10	100 tile
14 "	.025	.16	.065	.125	90 "
16 "	.035	.20	.075	.155	80 "
18 "	.04	.22	.085	.172	70 "
20 "	.05	.25	.10	.20	60 "
22 "	.06	.30	.11	.235	50 "
24 "	.07	.35	.15	.285	40 "
30 "	.09	.53	.20	.41	25 "
36 "	.13	.70	.30	.565	20 "
40 "	.16	.80	.36	.66	16 "

Screen for Inlet Pipe.

An inlet joint, or other pipe, which it is desired to screen, can be screened in the following manner: About an hour after the tile is made and before it has fully set, push pieces of wire through the walls in two directions at right angles to each other, as shown in the illustration. The size of wire and



size of mesh can be regulated according to the size of pipe and service desired. A 1-inch mesh will answer most purposes. Leave the wires this way until the tile has become thoroughly cured, then turn the ends down with a hammer to hold them in place.

Weight of Tile.

The following weights, taken from a manufacturers' catalogue, are given only as an average; the weight of concrete tile depends largely on the aggregate used in the manufacture. Tile 4 to 16 inches, inclusive, are 12¼ inches long; 18 to 24 inches, 2 feet long.

Size.	Weight.	——Average Car Load——	
4-inch	6 lbs. per foot	6,500 pieces	406 rods
5 "	8 " " "	5,000 "	312 "
6 "	11 " " "	4,000 "	250 "
7 "	14 " " "	3,000 "	187 "
8 "	18 " " "	2,400 "	150 "
10 "	25 " " "	1,600 "	100 "
12 "	35 " " "	1,000 "	62 "
14 "	48 " " "	800 "	50 "
15 "	55 " " "	600 "	37 "
16 "	65 " " "	500 "	31 "
18 "	75 " " "	200 "	24 "
20 "	87 " " "	166 "	20 "
22 "	100 " " "	160 "	19 "
24 "	115 " " "	150 "	18 "

Steam Curing.

Many inexpensive devices for curing cement products by steam are in use in different sections of the country, both for making sewer pipe, tile, block, brick and other products of this industry.

Dry steam should under no circumstances be used. Where steam curing process is to be employed, rooms should be provided which can be closed up reasonably tight and exhaust steam turned in from pipes running under the floor. No more than 5 pounds pressure should be used at any time on the pipe conducting this steam, and by means of this process the product can be cured much more quickly. Warmth accelerates the setting of the cement and the steam supplies sufficient moisture for a perfect crystallization.

Some successful steam curing plants have been erected without the use of a boiler of any kind, by simply using a few gasoline torches in curing the product, provided with thin pieces of sheet iron over the blaze with water dripping onto it. This water is turned into steam as fast as it drips and provides sufficient heat and moisture to cure the product in a first-class manner.

When the steam curing is used the product should be allowed to remain in the steam curing room or kiln from 18 to 24 hours, and the steam should not be turned on until the product is 12 hours old.

Making Y's and T's.

Connections can be made by simply cutting a hole in one joint and inserting another joint at the desired angle. The cutting can be done either before or after the concrete has set. Holes for the insertion of small sizes are readily made a short time after the pipe has been molded, when they can be cut out with a knife or

small trowel. For holes of large size this is not always practicable, as so much is cut away that the tile will not stand up. On this account it is necessary to cut the holes after the tile have partially cured.

The first thing necessary is care. While a concrete pipe is not as easily broken as a vitrified clay pipe, at the same time, if you go at it with a sledge hammer and strike heavy blows, you will break it to pieces; but, if you will be careful, you will experience no breakage in making this special pipe.

By way of an illustration: Suppose you wish to make a T joint for joining a 10-inch sewer pipe to a 24-inch main sewer. For this purpose you should have some pieces of 10-inch pipe made not over 12 inches in length, that is, 12 inches above the bell. Select a good, sound, well tamped 24-inch pipe from your stock that is two or three weeks old. It will cut best at this time, but can be cut at any time and at any age. Bed the large pipe in sand, so as to keep it from rolling, and give it a soft bed to lie in. Take the small section of pipe to be joined to it, cut it so that the end of it will fit the outer shell of the large pipe. Set the small pipe on the large pipe and with a pencil or sharp instrument, describe the circular line on the outside of the large pipe around the end of the small pipe, where you wish to cut the hole. Wet the large pipe thoroughly, then, with hammer and chisel, cut a line around the hole you wish to make about half an inch inside of the line that you have drawn. Keep on cutting carefully until you get about half way through the pipe all the way around; then cut the balance of the way through in three or four places about half way around the hole, and tap the piece gently from the inside, and the piece will come out easily, just where it has been cut.

Now trim or rim out this hole with a chisel until it fits the pipe that you wish to insert. After this hole has been trimmed so the small section will slide in easily, wet the end of the small pipe to be joined and the large pipe where it has been cut thoroughly, and go over it with a solution of neat cement of about the consistency of thick cream, a small brush being used. Then insert the small section of pipe in the opening where it is to be joined to the large pipe and brace from the inside so as to hold it in position, being careful that the end of the small section does not project beyond the inside of the shell of the larger pipe. After this has been firmly braced in position, mix up a cement mortar so it will handle easily with a trowel, about one part of cement and one part of fine sand, and fill around the junction. This junc-

tion at the angle where the two outside surfaces meet can be built up and strengthened in this manner with cement mortar to give any required strength, and it really becomes the strongest part of the pipe.

This joint is then wiped with a solution of neat cement, the same as was used at the start, the same as a plumber wipes a lead joint. In this manner a very strong and durable, as well as neat-looking, pipe is produced.

The next day the braces from the inside can be removed and the inside plastered, the same as the outside has been, with a rich cement mortar, and the inside made perfectly smooth by the use of the solution of neat cement and water applied with a small brush.

CHAPTER VII.

Methods and Cost of Manufacture (Continued.)

Cement Pipe in Southern California.

The manufacture of cement pipe for irrigation purposes in Southern California is quite an important industry. Water is king in the arid sections, where irrigation changes the desert to a garden of roses or an orange orchard, and its scarcity and economic value are so great that the most careful handling, with the least waste, are very necessary, especially to water the greatest possible areas with the limited water supply.

Originally, when the country was inhabited only by the native Indians and the early Spaniards, there were a few venturesome Americans who saw the great possibilities of the soil if it could only have water applied during the dry summer months, and these men built long dirt ditches or canals to bring the water from the rivers and mountain streams to their farms or ranches. And their efforts were rewarded a hundred fold. Their primitive methods continue in use in some parts of the state today, but the great waste of water in an open ditch has made this practice obsolete in all progressive communities, where the value of the water is realized, and only the most improved methods of bringing the waters to the orchards and fields are employed.

Very large streams are usually conducted to the irrigation districts in cement flumes, or in great cement pipes, and there distributed among the individual users in cement pipe lines of smaller sizes. Cement pipe 4 feet in diameter is used in some localities, and in a few places as large as 6 feet in diameter are in successful use, but it is not frequent that a regularly equipped pipe yard has an outfit for making pipe larger than 3 feet in diameter, which size is large enough to carry about 500 miner's inches of water on an ordinary grade. The other sizes vary from these 36-inch pipe down to pipe as small as 6-inch or 4-inch in diameter. These smaller sizes are used by the small farmer who has five or ten acres in orchard, and who uses from 10 inches to 25 inches of water at a "run."

These pipes are all made by hand, in "pipe yards," where it is left until it is sufficiently cured to be hauled out on the line to be laid. The pipes are made with tapering ends, which fit together snugly when laid, and the joints are carefully cemented together to prevent any leakage.

Skilled workmen are employed to make the pipe and lay it, and get good wages, but the mixing is done by ordinary laborers, and in some cases by machine mixers; but two good men can mix as much concrete as two experts can tamp into pipe in a day. A crew of four men, two expert makers and two mixers, will easily make 600 feet of 8-inch pipe in an eight-hour day, and 500 feet of 10-inch pipe and 400 feet of 12-inch in the same time, and will lay much more in a day than they can make. Two of my men often lay 1,100 feet of 8-inch pipe in a day, without a helper, and 1,000 feet of 10-inch pipe in the same time. The tools for making this pipe are ordinarily made at the local blacksmith shop, or boiler works, and consist of jackets, core, hopper, rimmer to make the tapered ends with, and a tamp, with enough cast iron "rings" to set the pipe on while the pipe is curing, to last a day's run. The pipe is all made in 2-foot joints, and can be turned off the rings in about 12 hours' time.

The concrete is mixed three times dry and three times wet, and is used in a comparatively dry mixture. One man throws the concrete from the wheelbarrow into the form with a scoop, as the other man tamps, and the men generally change places after tamping ten pipes, or 200 feet. The moulds are merely steel cylinders, with a simple locking device that is easy and quick to release and secure, and the core is another steel cylinder that also operates by releasing a lever on the inside, that allows it to contract sufficiently to be easily withdrawn. Two men carry the pipe away to its place in the yard as soon as they get it tamped, and while one man unlocks and removes the jacket, the other man has been placing the core in another jacket, and is ready to begin feeding for the next pipe as soon as the other man gets the other jacket released. Two jackets and one core usually make a set for one size.

Where the pipe is to be subjected to heavy pressure, it is sometimes reinforced with steel wire netting, and has proven very satisfactory.

Cement pipe is also extensively used for sewer pipe, and also for culverts in roads, and in some cases by railroads.

The thickness of the wall of a 6-inch pipe is 1¼ inches, of an

MAKING PIPE IN CALIFORNIA.

8-inch pipe 1½ inches, of an 18-inch pipe 2 inches, 36-inch pipe 3 inches.

Only the best of cement is used, and in a proportion of 1 part cement to 4 of sharp clean gravel. The two ends are made of a finer grade of gravel with one less part of gravel, or 3 to 1.

The large pipe lines of the irrigation companies conduct the water to the upper side of the different ranches, where a turn-out box or "well" is built with a measuring weir, to turn the water into the private pipe line of the rancher. These private pipe lines have a standpipe at each tree row, with a valve and four small outlet tubes, for letting the water into the furrows. Thousands of feet of this pipe are made and used annually.

Data from Another Source.

The following facts in regard to cement pipe in southern California are given by Mr. S. M. Woodward, Acting Chief of Drainage Investigations for the United States Department of Agriculture:

An 8 or 10-inch pipe will carry from ¾ to 1 cubic foot per second. It is said that an 8-inch pipe will carry 1.5 cubic feet per second on a grade of 1 per cent.

For the manufacture of jointed pipe various types of collapsible sheet metal forms are on the market. A crew of three experienced men can make per day:

500 feet of 8-inch pipe.
400 feet of 10-inch pipe.
350 feet of 12-inch pipe.
320 feet of 16-inch pipe.

A mixture of 1 to 4 or 1 to 5 of Portland cement and coarse sand is used in making pipe. The mixture is used in a rather dry state, in order that the forms may be removed from the pipe at once. In forming the pipe it is important that the material be well tamped. After standing for 24 hours, or better, 48 hours, the pipes are turned over and the metal rings removed from the ends upon which they have been standing. The pipe must be allowed to set for two weeks to a month before being used. During this time they should be kept damp by being sprinkled two or three times daily, and should be sheltered from the wind and from the direct rays of the sun. As soon as the pipe can be safely handled, their interior surfaces are washed with a mixture of neat cement and lime water to reduce the seepage, which is otherwise considerable while the pipes are new. A man can wash 60 2-foot lengths of 10-inch pipe per hour, using about a pound of cement per length. One barrel of cement will make 80 feet of 8-inch pipe with a mix-

ture of 1 to 5. Cemented joints are made with a mixture of 1 to 3.

Cement pipe is ordinarily considered safe for heads up to 14 feet. Results of scattering tests have been collected as follows: Two lengths of 16-inch pipe, united with a cement joint three weeks old, did not break under a head of 20 feet, or 9 pounds per square inch. A 10-inch pipe broke under a head of 20 feet. An 8-inch pipe did not break under a head of 46 feet, or 20 pounds per square inch. A line one-half long of 10-inch pipe, specially made of a 1 to 2 mixture, carries constantly a head of 20 feet.

The following table gives sizes and ordinary contract prices for pipe in southern California, with the price of cement at about $2.45 per barrel net. The price for pipe laid includes the necessary excavation and covering the pipe after laying. The price not laid for the pipe in the yard where they are made:

Size inside Diameter, inches.	Thickness of Walls, inches.	Depth of Bottom of Pipe, feet.	inches.	Price for Continuous Pipe, per foot, cents.	Price for Jointed Pipe laid per foot, cents.	Price for Jointed Pipe Not Laid, per foot, cents.
6	1⅛	2	6	18	16	9
8	1¼	2	8	20	18	12
10	1⅜	2	10	24	22	18
12	1½	3	0	30	28	24
16	...	.	..	..	45	40
20	...	.	..	..	60	50

There have been laid in southern California several hundred miles of cement pipe at a cost of $1,000 to $1,500 per mile.

Cost of Two Sizes on an Indiana Job.

During the summer of 1908 about four miles of cement pipe and tile were laid in Noble county, Indiana, on a project officially known as the Gretzinger ditch. The sizes varied from 8 to 24 inches, there being 5,300 feet of 12-inch and 2,760 feet of 24-inch. This work was visited by the writer while it was in progress, and the following facts were given by him at the time in The Cement Era:

For the manufacture of the tile the company has a portable shed, as shown in one of the illustrations. This, with the mixing boards, the easily handled Crescent molds, and a few light tools, constituted the outfit, which was easily moved from one place to another as the work proceeded, thus doing away with long hauls. The contract with the drainage district called for the manufacture of tile at four different points; but as the work progressed the advantage of working from another point became apparent, and an additional

move was made by the contractors without extra charge. This made the hauls shorter, the larger sizes for the most part being rolled into place. The breakage was thus reduced to a minimum, showing a decided advantage over clay tile, which has to be carried in freight cars and then hauled several miles in wagons. As a matter of fact, even under identical conditions concrete has a record of fewer broken tiles against it. On this present job the number of culls has not been carefully recorded, but it is considerably under 1 per cent.

A mixture of sand and gravel is secured from a bank in the vicinity and used on the work in the proportion of 1 to 4. It costs 10 cents a yard at the bank, and the distance is such that a man and team at $3.00 haul six yards a day, making the cost for hauling 50 cents, and a total cost of 60 cents per yard.

They are sprinkled each day for the first seven days, after which they are allowed to cure without other attention until they reach the age of thirty days, which is the period of curing demanded by the contract with the drainage trustees. The mixing on this job has all been done by hand.

On sizes up to 16 inches, two men on the mixing boards can keep enough concrete ahead for six or seven molders; on the larger sizes the work requires two mixers to four molders.

For the purpose of getting at the cost of production of these tiles, two sizes were chosen for particular observation—the 24-inch and the 12-inch. Of the 24-inch size, one man will make as high as 33 per day, the average of several days running at about 25. With wages at $2.00 per day, the cost for molders' labor is 8 cents on each tile. As on this size each molder requires half the time of a mixer, the mixer's wages must be added to this at 4 cents.

Observation showed that seven of these tile could be made from a barrel of cement and ten from a yard of gravel. With cement delivered on the job at $2.00 per barrel, this is a unit cost for cement of about 28½ cents. The gravel, we have seen, cost 60 cents a yard, making a cost of 6 cents on each tile produced. Incidentals, breakages, racking, etc., may be added at 7½ cents, making a total cost for each tile of 54 cents. They are made in 2-foot lengths, 500 to the 1,000 feet, making a cost per 1,000 feet of $270. The contract price on this size to the drainage district is $400 per 1,000 feet, showing a profit of $130. Clay tile of the same size is $425 per 1,000 feet, delivered at the railway station four miles away.

On the 12-inch size, a molder has made as high as 90 in a day,

VIEWS OF PLANT MAKING CONCRETE TILE AT KENDALLVILLE, IND.

averaging about 65. This makes his labor on each one cost 3 cents. As one mixer will mix for three molders on this size, one-third of the mixer's wages for the same time must be added, or 1 cent. One barrel of cement will make 29 tile, and one yard of gravel will make 40, thus giving us unit costs of 7½ cents and 1½ cents respectively. Adding 2 cents for incidentals, we have a total cost of 15 cents per 2-foot length of tile, or $75 per 1,000 feet, for which the contractors get $125 from the drainage district.

The data on these two sizes may be recapitulated as follows:

	24-inch.	12-inch.
Labor, molder	$0.08	$0.03
Labor, mixer	.04	.01
Cement	.285	.075
Gravel	.06	.015
Incidentals	.075	.02
Totals	$0.54	$0.15
Cost per 1,000 feet	$270.00	$ 75.00
Selling price per 1,000 feet	400.00	125.00

Concrete Pipe for Railroad Culverts.

During the summer of 1906 a number of pipe culverts were made by Mr. O. P. Chamberlain of the Chicago & Illinois Western Railroad and described by him in a paper before the Western Society of Engineers. He used the simplest form of pipe, a hollow cylinder whose bases are at right angles to its axis. These pipes were built of an inside diameter of 4 feet and an outside diameter of 5 feet, making the walls of the pipes 6 inches in thickness. These pipes, which resemble in shape the hollow clay tiles used for tile drains, have been placed in low embankments where their tops are but 18 inches below the under sides of the cross ties. They were simply placed end to end in shallow ditches conforming with the outside surface of the pipes as nearly as it could be done by picks and shovels and the back and top filling of the earth embankment thoroughly tamped around and above the pipes. Thus far they have given satisfactory service under heavy freight traffic.

Forms are of wood, of ordinary wooden tank construction. The inner form has one wedge shaped loose stave which is withdrawn after the concrete has set for about twenty hours, thus collapsing the inner form and allowing it to be removed. The outer form is built in two pieces with heavy semicircular iron hoops on the outside, the hoops having loops at the ends. When the two sides of the outer form are in position, the loops on one side come into position just above the loops on the other side, and four steel pins are inserted in the loops to hold the two sides together while the

form is being filled with concrete and while the concrete is setting. After the inner form has been removed, the two pins in the same vertical line are removed and the form opened horizontally on the hinges formed by the loops and pins on the opposite side. The inner and outer forms are then ready to be set up for building another pipe.

The concrete used in manufacturing these pipes was composed of American Portland cement, limestone screenings and crushed limestone that had passed through a ¾-inch diameter screen, after everything that would pass through a ½-inch diameter screen had been removed. The concrete was mixed in the proportions of 1 part cement to 3½ parts each of screenings and crushed stone. All work except the building of the forms was performed by common laborers. The cost of these pipes built under these conditions was $2.50 per lineal foot. This high price was due, in part, to the small scale on which the work was carried on, and amounts to $9.62 per cubic yard for the cost of the concrete. It should be possible to manufacture these pipes in quantities, using enough forms to keep one or two laborers steadily at work, for $7 per cubic yard, including the cost of forms. This is equivalent to $1.83 per lineal foot of 4 feet inside diameter concrete pipe. The cost of the lightest cast iron pipe of the same diameter is $19.50 per lineal foot.

The following table shows the comparative weight and cost of concrete and "Standard" cast iron pipes from 1 foot up to 4 feet in diameter; it is based on the above price of $7 per cubic yard for concrete and 3¼ cents per pound for cast iron pipes.

TABLE SHOWING RELATIVE THICKNESSES, WEIGHTS, AND COST OF "STANDARD" CAST IRON PIPE AND CONCRETE PIPE.

Size and kind of pipe—	Thickness in inches.	Weight lbs. per lin. ft.	Cost per lin ft.
12 inches diameter, cast iron	0 $\frac{33}{64}$	75	$ 2.44
12 inches diameter, concrete	2	88	0.16
18 inches diameter, cast iron	0 $\frac{47}{64}$	167	5.43
18 inches diameter, concrete	3	220	0.36
24 inches diameter, cast iron	1	250	8.13
24 inches diameter, concrete	4¼	420	0.68
30 inches diameter, cast iron	1$\frac{1}{16}$	334	10.86
30 inches diameter, concrete	4½	602	0.88
36 inches diameter, cast iron	1⅛	450	14.63
36 inches diameter, concrete	4¾	676	1.10
42 inches diameter, cast iron	1⅜	600	19.50
42 inches diameter, concrete	5¾	960	1.55
48 inches diameter, cast iron	1$\frac{7}{16}$	725	23.56
48 inches diameter, concrete	6	1131	1.83

In the above table the thickness for concrete pipes of various diameters have been taken as approximately proportional to the thickness of "Standard" cast iron pipes of the same diameter, the 4 feet diameter pipes being used as a basis for calculation.

The first cost of concrete pipes at the place of manufacture would, according to the above table, be less than one-twelfth of the cost of cast iron pipes. The cost of transportation and of installing the pipes would, on account of the greater weight and greater number of pieces, probably be very nearly double for concrete pipes, what the same service would cost for cast iron pipes.

On account of the lack of reliable data regarding this cost, Mr. Chamberlain was unable to give a fair comparative estimate of the cost of the two styles of culverts in place. However, since transportation and installation of iron pipes is but a small proportion of the cost of the completed culverts, it is evident that cost of a concrete pipe culvert in place would be but a small fraction of the cost of a cast iron pipe culvert of the same diameter, provided the pipes were hauled only moderate distances.

A type of concrete pipe has, after considerable experimenting, been designed bv Mr. C. H. Cartlidge and adopted by him for use on the Chicago, Burlington & Quincy Railway.

This type of pipe has been made in sizes of 2, 3 and 4 feet inside diameter. It has, in the opinion of Mr. Cartlidge, passed the experimental stage and is being used extensively on the Chicago, Burlington & Quincy Railway. This pipe is heavily reinforced by corrugated steel bars, the annular bars being so curved and placed as to be near the inside at the top and bottom of the culvert, and close to the outside on the sides of the pipe, so as to gain the greatest efficiency from the tensile strength of the reinforcing bars.

The shape of these pipes is very nearly that of the ordinary cast iron pipes, the bell and taper ends being as nearly like those of the cast pressure pipes as the nature of the materials will admit. The provisions for expansion and vertical depression are ample.

Reinforced Concrete Pipe Sewer in Indiana.

The city of Mishawaka, Ind., added nearly six miles of concrete sewer to its sewer system during the summer of 1908, this amount including 17,000 feet 42 inches in diameter, which was in progress at the time the work was visited.

The sewer is of reinforced concrete, made in 3-foot interlocking sections on the system patented by the Reinforced Concrete Pipe Company of Jackson, Mich. In the 42-inch size, each section

BUILDING A 42-INCH CONCRETE PIPE SEWER AT MISHAWAKA, IND.

is reinforced longitudinally by five bars, as well as by two transverse circular bands. The forms are assembled by first setting up the inner wall in rolled steel sheet sections on the upper and inner flange of the bottom plate or ring; then the lateral reinforcing bars are inserted in pockets in this ring, disposing them at right angles to the diameter; next the outer wall, in rolled sheet steel sections, is assembled on the lower and outer flange of the bottom plate, and space clips at the top of this wall hold the reinforcing bars in position. The process of making is then shoveling and tamping until one-fourth of the pipe section has been tamped. Then the space clips are removed and the first circular or band reinforcement is added, being gauged in position by means of slot punches which receive and accommodate the reinforcing bars. After the space clips have been again adjusted the tamping proceeds until the second band reinforcement is added at three-quarters of the pipe section. The reinforcing bars in each pipe section protrude into the rectangular ends of the section with hooked ends, so that the reinforcing of each pipe section individually provides the means for interlocking each section with the other.

The thickness of one end of each section is reduced by a rectangular rebate, and by a beveled edge, both extending around the circumference. The other end is correspondingly flanged so that when the several sections are laid in position, the contact by entrance of one end to the other gives a smooth surface on the inside and leaves a uniform groove on the outside at the joints of the assembled sections. The longitudinal reinforcing bars in each section protrude with hooked ends into the rebated space which forms the outside groove when two sections are placed together in position. The sections are then interlocked by a tie-band which passes completely around the sections in the grooves at the joint and through the hooked ends of the longitudinal reinforcing bars.

This system permits of manufacture along the line of the sewer, the gang at the molds making as much each day as the laying gang can put in place, and sufficiently far ahead to allow the sections time to season before being put under ground.

The contractor, who has personal charge of this job, found considerable trouble in getting satisfactory labor to manufacture the sections, and with six men at $1.60 per day and with himself giving a large amount of his time to looking after them, he was scarcely able to turn out the 60 feet which it was planned must constitute a day's work.

He thereupon secured five Hungarians and told them that he

would pay them $9 per day collectively, or $1.80 each, to turn out 60 feet, and that they could quit when that amount of work had been done. The deal was made, and at the time the writer visited the job it was working like a charm. The contractors were getting the full daily quota of sections without trouble or waste of their own time, and the Hungarians were likely to stick to their job, as they were making 20 cents a day more than the other men, in addition to getting away an hour or more before quitting time each day.

With the men making 60 feet at $9.00, the contractor can figure on an unvarying unit cost of 15 cents per foot. The excavation from the trench furnishes a very good grade of mixed sand and gravel, which is used in making the sections, being mixed with cement in the proportion of 1 to 5. As the haul is short, one man and team at $4.00 per day will haul enough sand and gravel in one day to keep the men busy two days. This $4.00 must therefore be equalized over 120 feet of pipe, making a cost on this item of 3⅓ cents per foot. It takes 55 sacks of cement, or 13¾ barrels, for each day's work. At $1.35 per barrel, delivered on the job, this makes a daily cost for cement of $18.56, or practically 31 cents per foot. Adding these items we get the following results:

Men on forms	$0.15
Hauling sand and gravel	.03⅓
Cement	.31
Total cost per foot	$0.49⅓

Of course, this does not include the reinforcing, which is furnished by the Reinforced Concrete Pipe Company, nor the royalty paid to that company for the use of its forms.

Some Oregon Figures.

Mr. Albert E. Wright gives the following account* of the method and cost of molding and laying 6 to 12-inch cement pipe for work at Irrigon, Oregon: The pipe was 6 to 12 inches inside, made of Portland cement and clean, sharp sand of all sizes up to very coarse. The mortar was mixed rather dry, but very thoroughly, using 14.1 cubic feet of sand to 1 barrel of cement, or very closely a 1 to 4 mixture. From six to seven buckets of water were used to each barrel of cement, except for 6-inch pipe, for which the mortar had to be made somewhat stiffer in order to

* "Concrete Construction: Methods and Cost," by Gillette and Hill.

remove the inner form, which was not made collapsible as in the larger sizes.

The forms were sheet iron cylinders with a longitudinal lap joint that could be expanded after molding the pipe, and removed without injuring the soft mortar. The inner form was self-centering, so that there was little variation in the thickness of the pipe.

Four men were required in making cement pipe by hand; one mixed the mortar, and wheeled it to the place of work; another threw it into the form a little at a time with a hand scoop; a third rammed it with a tamping iron, and a fourth kept the new pipe sprinkled, and applied a coat of neat cement slurry to the inside when it was sufficiently hard. In molding, the form of the bell at the bottom was secured by an iron ring that was first dropped into the form, and the reverse or convex form at the top was made with a second ring. While still in its form the pipe was rolled or lifted into its place in the drying yard, and the form was then carefully removed. A very slight blow in removing the form would destroy the pipe, and a considerable number, especially of the larger sizes, collapsed in this way, and had to be remolded. To avoid handling, the pipe was stacked on end a few feet from the place of mixing, the form being moved as the yard filled with pipe. One crew of four men could make about 250 joints or 500 lineal feet of pipe a day.

As soon as hard enough, the pipe was turned end for end, and was then kept wet for several weeks before being laid. The coating of neat cement on the inside was applied with a short whitewash brush, and was a small item in the cost.

In laying, the trench was carefully finished to grade in order to have the joints close nicely, and the ends were well wet with a brush. The mason then spread mortar, mixed 1 to 2, on the end of the pipe, and laid a bed of mortar at the bottom of the joint. He then jammed the section into place, and swabbed out the inside of the joint with a stiff brush, to insure a smooth passage for the water. A band or ring of mortar was spread round the outside of the joint as an additional reinforcement. One barrel of cement would joint about 300 sections of pipe. The materials cost as follows: Portland cement. per barrel, $4.45; labor, per day, $2; foreman, per day, $2.50 to $3; hauling, per load mile (1 cubic yard), 20 cents; sand, free at pit; water, free.

By carefully working out the voids, and the amount of cement required, the following cement costs per foot were arrived at, cement being $4.45 per barrel:

Diameter, inches.	Thickness, inches.	Cost, per foot.
6	1¼	$0.0571
8	1¼	0.0730
10	1⅜	0.0998
12	1½	0.1278

The sand cost was based on 15 cents per cubic yard for loading, and a haul of two miles of 1 cubic yard to the load, making five trips per day, at $4 for man and team. It bears a constant ratio to cement cost, being 11.2 per cent of the cement cost. The labor cost of making was based on the foreman's estimate that a foreman, tamper, mortar mixer, and water man should finish 250 joints a day of 6 or 8-inch pipe. For the 10 and 12-inch pipe, the labor was assumed to be greater in proportion to the material. The foreman was taken at $3, one man at $2.50 and two at $2. The cement for painting the inside was neglected. Hauling the pipe to place was taken at twice the cost of hauling the sand per mile, and a haul of four miles was assumed. The cost of laying was based on a foreman's estimate of 2 cents per foot for trench, and that one man to lay, one man to plaster the joints, one helper and one man to backfill would lay 600 feet per day of 6 or 8-inch pipe. The larger sizes were assumed to cost more in proportion to their material.

These various costs gave the following results for small size pipe:

	Cost per foot for			
	6-inch pipe.	8-inch pipe.	10-inch pipe.	12-inch pipe.
Cement	$0.057	$0.073	$0.099	$0.128
Sand	0.006	0.008	0.011	0.014
Labor	0.019	0.019	0.026	0.034
Hauling	0.024	0.032	0.044	0.056
Laying	0.024	0.024	0.032	0.042
Trench	0.020	0.020	0.020	0.020
Totals	$0.150	$0.176	$0.232	$0.294

Reinforced Pipe at Pueblo, Colo.

More than 18,000 linear feet of hub and spigot concrete pipe, in 30 and 38-inch sizes, was made in connection with the development of a water system at Pueblo, Colo., as described in *The Engineering Record* for April 4, 1908. This pipe was all in 2-foot lengths, the shell of the 38-inch size being 3¼ inches and that of the 30-inch size 2½ inches thick. The concrete was made in the proportions of 1 part Iola Portland cement to 4½ or 5 parts of gravel obtained from the river, depending on the percentage

of voids in the gravel. The latter was of excellent character for the purpose, varying from sand to stone that would pass a $\frac{3}{4}$-inch screen. The concrete was all mixed by hand, and was thoroughly hand-tamped in the molds in which the pipes were cast.

The concrete pipes were made at a cost below that of any other satisfactory material that could be delivered at the work. This low cost was largely due to the fact that the aggregate for opening, in order to produce a joint that will not cause any deformations on the inner surface of the pipe. The two parts of the outer shield are fastened together with lock levers of very simple design, these levers and locks being attached to the reinforcing angles. The shield is placed on the base ring, the latter being made so it forms the hub of the pipe.

When a mold has been set up, the concrete is placed in it in about 4-inch layers, and each layer thoroughly tamped. In order to insure good results in tamping it has been found that three men were required to a mold. The concrete is made dry enough so that water would flush to the surface only under thorough tamping, and requires considerable skill to mix properly. After filling a mold to the top of the shield, a ring of sheet steel, built as a section of an inverted circular hopper, is laid on the shield. This ring is of such size that a space remains between it and the core, the latter projecting above the top of the shield, so concrete can be shoveled into this space and built up to form the spigot end of the pipe. When a sufficient amount of the concrete for the spigot has thus been placed, the light steel ring is removed and replaced by a heavy cast iron ring, with a cross section the same as that of the spigot of the pipe. This ring fits closely around the core, and by revolving it the spigot is easily and accurately formed. A gang of three molders could cast sixteen 2-foot sections of 38-inch pipe and twenty 2-foot sections of 30-inch pipe in this manner in ten hours.

The dry mixture of concrete was required in order that the molds could be removed immediately after the pipe was cast. The pipe made in the manner described stood alone when perfectly green, without any signs of weakness. Each pipe was left on the base ring about 72 hours, depending on atmospheric and other conditions, before it was upended and the base ring removed. During this time the section was sprinkled continuously.

The first pipes were made at the river end of the 30-inch waste line, but soon after the work was started cold weather set in, so a 50x100-foot frame warehouse, ceiled with corrugated sheet

iron, was erected adjacent to the main gathering gallery, and the remainder of the pipe made in this warehouse during the winter. Sheet-iron stoves were installed to maintain the temperature in the building, and other precautions were observed to protect the new pipe from freezing.

The cost of the first pipe made was somewhat higher than the average, owing to the inexperience of the molders, and to other causes, but was at no time up to the cost of other material that could be used. The average cost of the plain pipe when made in the warehouse was very close to $1 a foot for the 38-inch size and 75 cents a foot for the 30-inch size. The cost of the reinforced pipe was increased over that of the plain practically by the cost of the reinforcing material, as the method by which the concrete was placed in 4-inch layers in making the plain pipe permitted the reinforcement to be inserted without added expense. The costs given include every expense, even to a proportionate charge for construction camp expenses, the watchman's salary, coal for heating the warehouse, and the labor required in rolling the pipes out of the warehouse. Laborers were paid $2 and a foreman $3 a day, the one foreman running the whole gang. The cement cost $2 a barrel at the railroad station, two miles from the work. The gravel was hauled about one-half mile with teams at 40 cents an hour, each team hauling six or seven 1 cubic yard loads in 10 hours.

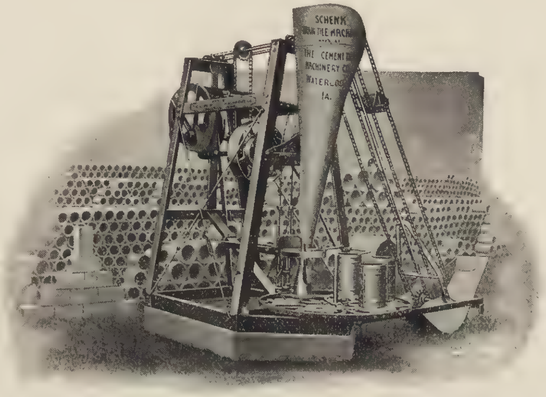
CHAPTER VIII.

The Machines on the Market.

Schenk Cement Drain Tile Machine.

This machine is manufactured by the Cement Tile Machinery Company, Waterloo, Iowa. It consists essentially of a pyramidal frame about 8 feet high, a revolving table for carrying the molds, a revolving shaft carrying the packer head, a boot from which the molds are filled, and a bucket elevator which delivers concrete to the boot.

The tile are made in galvanized iron jackets, made in two parts, and provided with hinges and lock. These jackets set on pallets carried by the revolving table, the table carrying six pallets of any size. These pallets are held by pins in the table, the change from one size to another being made by simply lifting off one set of pallets and dropping another into place.



SCHENK POWER MACHINE.

The table is revolved and the jacket placed in a position for making tile by means of a cam at the rear of the machine. There is a ring, or rather a combination ring and a small hopper, which

THICKNESS OF SHELL ADOPTED BY THE DIFFERENT MANUFACTURERS OF TILE MACHINES AND MOLDS.

Diameter, in.	4	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	27	30	33	36	39	40	42	48	54	60	66	72
Reinforced Concrete Pipe Co.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2½	..	3	3½	3¾	4	4¼	..	4½	5	5½	6	6½	7
Hudson Mfg. Co.	¾	⅞	⅞	..	1	1	1¼	1⅜	1½	1½	1⅝	1⅝	1¾	2	2	2	..	2½	..	3	..	..	..	..	..	..	..	..
Raber & Lang	¾	¾	¾	⅞	1⅛	1¼	1¼	1⅜	1½	1½	1⅝	1⅝	1¾	..	2	..	..	2½	..	3	..	..	..	..	..	..	..	..
Ferguson Power Machine	½	9/16	⅝	11/16	¾	..	⅞	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Schenck Power Machine	½	9/16	⅝	11/16	¾	..	⅞	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"Easy" Molds	..	..	..	..	..	..	..	1¼	1⅜	..	1½	1⅝	1¾	1⅞	2	..	..	2½	..	3	..	3½	..	..	..	..	..	..
Miracle Molds	¾	1	1	..	1	1⅜	1⅜	1½	..	1⅝	1⅝	1¾	1¾	..	2	2	..	2½	..	3	..	..	..	..	..	..	..	..
Miracle Power Machine	½	½	⅝	⅝	11/16	..	¾	⅞	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"Electric" Power Machine	⅝	⅝	¾	¾	¾	..	⅞	1	1¼	1⅜	1⅜	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"Electric" Hand Molds	..	..	..	..	..	..	..	..	..	..	..	1¾	2	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..
Besser Power Machine	½	9/16	⅝	¾	⅞	..	1	1	1⅛	..	1¼	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Besser Hand Molds	..	..	1¼	..	1½	..	1¾	2	..	2	..	2	2⅛	..	2⅛	..	..	2½	..	3	..	..	..	..	..	..	..	..

drops down on to the jacket after it is revolved into position, and holds the jacket solidly in position while the tile is being made.

When the jacket is in place, the packer head, which is on a sliding shaft, operated by another cam at the rear of the machine, drops down through the jacket and into and fills the bottom ring; and just at this point, where the packer fills the ring, the concrete is dumped in from the top by means of the elevator. The cup on the elevator holds just enough material to make a tile, different cups being put on for the different sizes. Thus the concrete is dumped down inside of the jacket and around the packer, and the packer head revolves up through the concrete and packs, forces and presses the material between the jacket and the packer. This packer head has concave sides and is graduated out from the size of shaft on which it revolves, to the full size of the inside of the tile at the lower end. Thus, it is in one sense the core, for it forms the inside of the tile, and revolves up out of the jacket through the top ring, and the ring rises with it and releases the jacket, and the tile is made; then the table revolves and another jacket moves into place.

As the tile are made they are removed from the machine and taken to the drying shelves where the jackets are taken off.

Crescent Sewer Pipe and Drain Tile Machines.

These machines are made at Kendallville, Ind., by the Raber & Lang Mannfacturing Company.

The Crescent mold is very simple in construction, consisting of an iron pallet, an outer hinged shell, a collapsible core and cap for same, and a tamper. To these must be added the bell former for bell-end tile. The outside casing and the core are of heavy sheet steel, reinforced at the top with angle steel to avoid all possibility of getting out of shape in the process of molding. At the lower ends they are held in place by the pallet, which is a circle of cast iron fitting accurately between the core and outer shell. This latter is made in two parts, hinged together with patented lock hinges which can be fastened during the process of molding in such a way as to maintain complete rigidity, at the same time allowing the mold to be opened at once without in any way injuring the tile. Locks are of course provided also on the front of the mold where the two parts come together. The core, as stated, is made of sheet steel, which is curved into shape in such a way that the edges work past each other. In a state of repose the core is somewhat smaller than its working size. By a simple and easily

operated device it is expanded and locked in place for working. The lock is released by reversing the lever, the elasticity of the steel collapsing the core sufficiently to allow it to be withdrawn.

The method of manufacturing the tile is as follows: The iron pallet is placed on the floor or ground where the machine is to be operated, the core is locked inside, and the conical cap is placed

CRESCENT MOLDS.

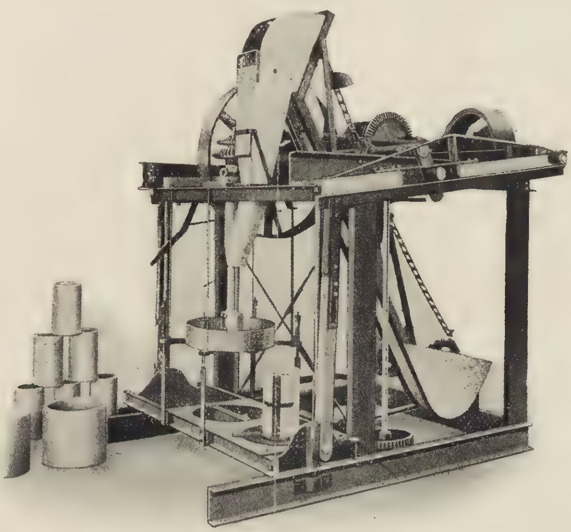
over it. This cap is, of course, for the purpose of keeping the concrete from falling into the core. The outer shell is then locked in place, and the mold is ready to be filled. The concrete is shoveled in three or four shovelfuls at a time, and thoroughly tamped with tampers which fit the shape of the mold. The tile is then removed on a truck to the drying yard, where the core is first removed, and then the shell, leaving the tile standing on the pallet.

The same company also manufactures the Crescent automatic

power tamper, the operation of which is as follows: The sand, cement and gravel are first dumper into the mixer, where it is dry and wet—mixed thoroughly, after which it is automatically fed into the receiving trough, provided with spiral conveyors and then fed directly into the mold through the hopper. The table on which the mold is locked is automatically rotated and lowered, the movement of the tamps likewise governed, and in the meantime the pipe or tile is becoming thoroughly tamped and completed.

Ferguson Patent Cement Drain Tile Machine.

The Ferguson machine is manufactured by the St. Paul Cement Machinery Company, 510 Endicott building, St. Paul, Minn. Manufacturers claim that the machine alone can be operated by three or four-horsepower, 10-horsepower being ample for tile machine, concrete mixer, sand screen, etc. Machine has a square upright plane and the pallets are carried on a sliding rack which holds two pallets, so that as one finished tile is carried away, another jacket



FERGUSON POWER MACHINE.

slides into place. The power head is made in two parts, the main part attached to the shaft revolving at one speed while the wings attach outer shaft revolving at a much higher speed, pressing the concrete outward against the walls of the jacket and troweling it down smooth.

When the carriage is at its highest point the head fills the lower ring, or pallet; then the concrete is dumped in automatically, the head revolves continually and forms the tile. When the carriage is at its lowest point the table shifts automatically and the tile in the jacket is taken to the curing shelves, where the jacket is removed immediately and returned to the machine.

The machine is set in motion by a lever which operates a friction clutch. The lever at the left of the machine is used to start the cable. After this is put in motion, the concrete is thrown into the hopper, the buckets taking up a sufficient amount for one tile. This is dumped in just at the time the carriage is at its highest point. The head at once presses the concrete against the jacket and as the carriage is lowered, the tile is formed. The cable then shifts to one side, putting the finished tile in position to be put away and bringing another jacket into position under the tamper. The machine makes tile from 4 to 16 inches in diameter.

Wolverine Drain Tile Mold.

This mold is made by the Cement Machinery Company of Jackson, Mich. It consists of a small standard on which sets the

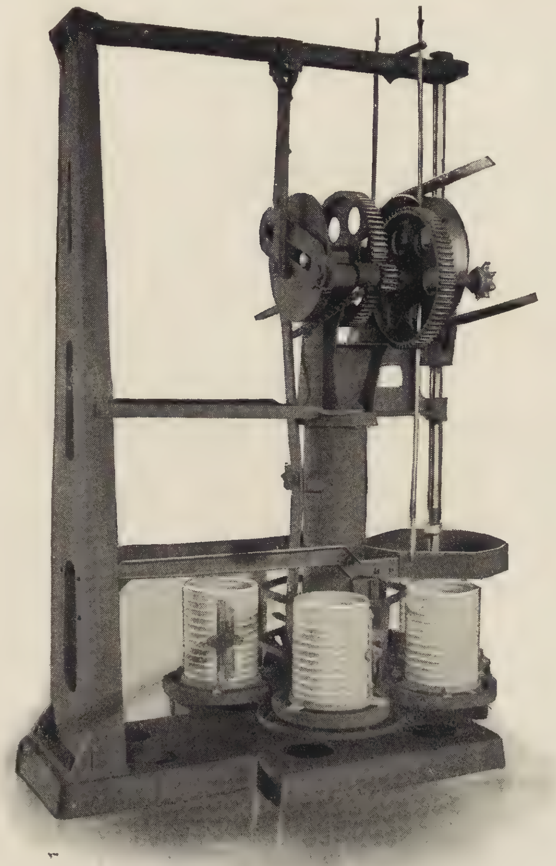
WOLVERINE MOLDS.

inner form, which runs up to a conical top. Around this is placed the jacket, which rests firmly against a flange in the pallet. Hinged to the standard is an arm carrying a cylindrical funnel, which can be closed down tightly upon the outer shell, thus forming a re-

ceptacle into which the concrete can be thrown. It is then tamped into the mold by hand.

The Miracle Power Tile Machine.

The Miracle Presed Stone Company, Minneapolis, Minn., are manufacturers of this machine. It consists of a base from which



MIRACLE POWER MACHINE.

rises a hollow shaft carrying the operating mechanism, and around which shaft revolves the table carrying the molds.

The tile are made by means of a peculiarly shaped revolving packer which operates inside the steel mold or casing. The circular table around the column of this machine is moved vertically by the mechanism and carries the casing with it. When the table or carriage is at its highest point the packer completely fills the ring or pallet upon which the casing rests. At this moment the machine automatically dumps the proper amount of concrete into the casing, which then goes downward with the table and the revolving packer gradually moves up inside the casing, forcing and packing the concrete against the latter and forming the tile. When the casing reaches the bottom, the packer and casing are free and the table revolves and brings the next casing into position, and the operation is repeated. In the meantime the tile are carried away in the casing to the curing shelves. The casing is then removed from the tile and returned to the machine to be used over again.

The packer head of this machine is made reversible, so that when worn out in one position by the grinding action of the sand, it can be used in another.

The manufacturers claim that 6 to 8-horsepower is ample for operating the machine.

A Glazed Cement Sewer Pipe Machine.

James Thomas, Tacoma, Wash., has recently perfected a machine for the manufacture of glazed cement sewer pipe, an illustration of which is shown herewith.

The machine consists of a revolving table, on which is centered a jacket, held firmly to the table by catches screwed into the table. A core shaft is socketed in the center of the table and on this the core is fastened. The core shaft passes up through a feathered sleeve, and at the upper end the hoisting cable is attached. After passing over a pulley at top of machine the cable comes down and passes three times around a counter-weight drum, and below this is attached a counter-weight bucket, and the weight of the core and shaft is neutralized by loading the bucket; another cable attached to the drum, drawing in the opposite direction, passes over a pulley and down to the windlass at the right hand of the machine. When the pipe is complete, while the table is still revolving, the

core is drawn, the pipe carried away and the jacket (which is in two parts) is taken off, leaving the finished pipe standing on the small end. The revolving table distributes the feed, also the tamp-

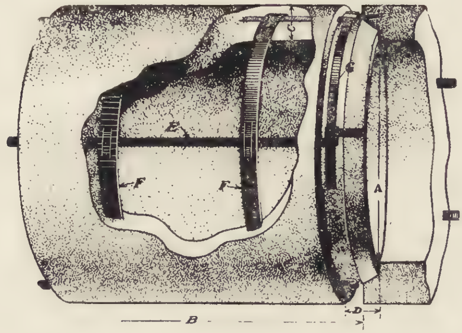
MACHINE INVENTED BY JAMES THOMAS, TACOMA, WASH.

ing, dresses the inner-surface and facilitates the discharge of the core. At the time the photo was taken only the frame of the tamper was in place. The tamping is done on the walking-beam

principle, striking over 250 blows per minute, making a product so dense that after a short period of leaching, stands full of water.

Reinforced Concrete Pipe.

The reinforced Concrete Pipe Company, Jackson, Mich., makes a pipe which is shown in the accompanying illustration.



SYSTEM OF REINFORCING.

Each pipe section is reinforced individually. The forms for making pipe are assembled by first setting up the inner wall in rolled sheet steel sections on the upper and inner flange of the bottom plate or ring, then the lateral reinforcing bars are inserted in pockets in this ring, disposing them at right angles to the diameter, next the outer wall, in rolled sheet steel sections, is assembled on the lower and outer flange of the bottom plate and space clips at the top of this wall hold the reinforcing bars in position. The process of making is then shoveling and tamping until one-fourth of the pipe section has been tamped. Then the space clips are removed and the first circular or band reinforce is added, being gauged in position by means of slot punches which receive and accommodate the reinforcing bars. After the space clips have been again adjusted the tamping proceeds until the second band reinforce is added at three-quarters of the pipe section.

The reinforcing bars in each pipe section protrude into the rectangular ends of the section with hooked ends, so that the reinforcing of each pipe section individually provides the means for interlocking each section with the other.

The Besser Machines.

The Besser Manufacturing Company, of Alpena, Mich., manufacture three separate tile machines. They are known as the Besser power drain tile machine, the Automatic Tamper drain tile machine, and the Quick Working tile machine.

The power tile machine has a rectangular steel frame and the jackets are carried by a circular revolving frame which holds five jackets. The table is revolved automatically as each tile is completed, bringing the next jacket in place under the packer head. It makes tile 12 inches long and from 4 to 15 inches in diameter.

The Automatic Tamper machine makes tile the same length and in sizes of 2, 3 and 4 inches. No power is required for this machine. The tamper is the size and shape of a finished tile, except that it is longer, and consists of a hollow circular iron plunger which works up and down on the outside of an inner drive. The tamper is suspended on a strong spring of appropriate dimensions in such a way that it raises and lowers the full length of the stroke almost automatically. Each machine has double table carrying two cores, so that as soon as one tile is completed, another mold can be swung into place. A large hopper at the back receives the material, from which it is drawn into the round hopper on the machine as needed.

The Quick Working tile machine has a small hand contrivance for making tile from 2 to 12 inches. It consists of a table similar to the tables on the automatic tamper machine, with the same arrangement at core, casings, centering and raising device, etc., but the tamping is done by hand with an iron tamper.

For larger sizes, the company also makes hand molds to suit all purposes.

Hudson Molds.

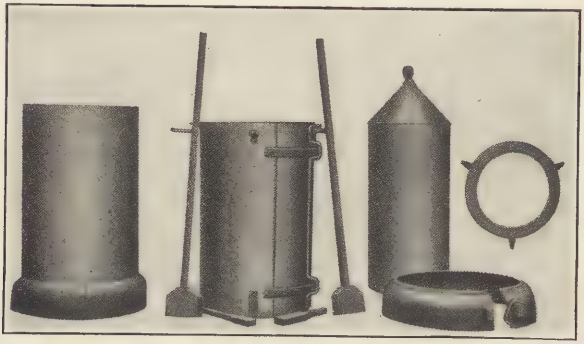
The Hudson Manufacturing Company, Hudson, Ind., make a series of hand molds for tile from 4 to 36 inches. The outer case is made to open directly away from the finished tile so that there is no danger in removing it. The inside case is contracted by a very simple device. Each outfit is furnished with a hopper, cone and tamper. Extra outfit for bell end pipe can also be secured.

Miracle Hand Molds.

The Miracle Pressed Stone Company, of Minneapolis, also make hand molds for straight, bell-end, and bevel-and-tongue pipe. The

following directions for working these are given by the company:

In making bell-end sewer pipe the inside casting for the bell or pallet should be kept free from rust by dipping in crude oil or a solution of paraffine to prevent it from sticking to the concrete, and cause it to remove easily from the finished product after it has set. Place the inside iron ring on a wooden pallet or on the floor, so that it sets firm and level with the outside of the bell mold, clamp around it with "U" shaped clamps. The three projecting lugs or points serve to space the outside ring evenly, which is of proper shape of the outside of the bell of standard shape. This ring consists of two pieces, fastened together by a "U" shape fastening device. Then set the sheet-iron cone in place on the inner ring,



MIRACLE MOLDS WITH BELL-END ATTACHMENT.

shovel and tamp in as much material as possible. The tamping into the bell should be done thoroughly, using a regular tamper, placed at an angle of about 45 degrees, so as to tamp back in under the shoulder of the bell. Care should be taken that the material is very firmly packed under this overhanging portion of the outside of the ring. Scoop out any surplus material, remove the cone and place the inside casing in place, expanding it to its largest size. After the inside casing is put in place, a few handfuls of material should be placed in the mold and tamped once around, so as to fill up the mold nearly level with the top of the outside of the bell, then place the outside casing in position, contracting it to its smallest size by the outside lever for that purpose. Lugs on the inside bell casting hold the inside core in position and lugs on the outside bell casting hold the outside casing in position. Then place the cone on the

inside casing or core, and commence shoveling in the material and tamp carefully, thoroughly and evenly. Be very careful in tamping the bottom of the pipe, so as to preserve an even thickness of the pipe all the way around. The tamping should begin immediately after the first shovelful of material is placed in the mold.

One man is sufficient to tamp up to sizes 20 to 24 inches in diameter, after that two men work together to better advantage. Under no condition should the mold be filled half full before being tamped. The tamping should be done carefully, striking even and regular blows, and care should be taken that the same amount of tamping is given entirely around the circle. A little practice will enable the operator to make absolutely perfect tile.

After the mold has been tamped full, remove the cone and finish the tile on the top with a trowel cut to fit the circular form of the mold. The inside core is then contracted and lifted out. One man can handle the cores for all sizes of pipe up to 15 inches in diameter. In sizes larger than this use the lifting bar with hooks, and two men should be used to remove the cores. Then loosen the "U" shaped fastenings which hold the bell in position, before loosening the outside casing, then expand the outside casing to its fullest size and remove it carefully. Then remove the outside of the bell attachment by taking off the "U" shaped fastenings and sliding the two parts of the bell attachment away from the finished tile. The inside ring for the bell must remain in place for about two days until the pipe is of sufficient strength to lay out on its side when the inner ring is removed, by a slight tapping from the inside. The best way to remove these rings is to tamp the top edge, which projects inside of the pipe, tipping the pipe at a slight angle, and tamp the ring lightly, which will loosen it quickly.

In the operation of removing the casting of the outside bell, great care should be taken that the green pipe is not jarred or injured, as it is very fragile at this time.

In making bevel-and-tongue pipe the bottom ring is placed in position on the floor, or on a wooden pallet, the same as the inside casting for the bell-end pipe. The inside casing is placed inside of this and expanded to its fullest size and the outside casing is placed outside of it and contracted to its smallest size. Filling and tamping should proceed the same as in making bell-end pipe or straight pipe, and when the mold is tamped full, the finishing ring with two handles is used to finish the pipe at the top, making the opposite of the groove at the bottom. The inside and outside casings are then removed, the same as before.

"Easy" Hand Molds for Large Sizes. Tile

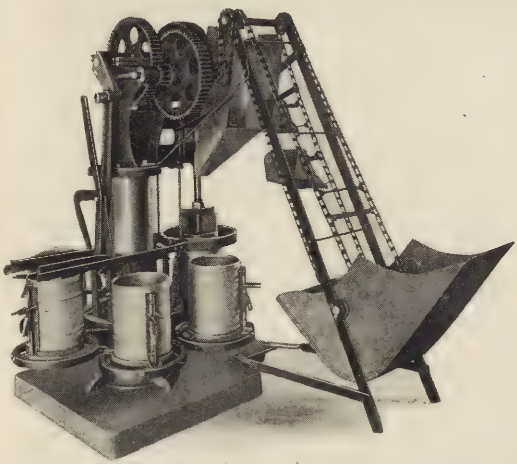
These molds are made by the [redacted] Cement Machinery Company, Waterloo, Iowa. The core is made in three parts, which are quickly put together and as quickly collapsed. This core has an ingenious fastening device on the inside, which, when sprung open, will allow one to quickly take out the core in three parts without the danger of disturbing the newly made tile.

The outside casing is made in two equal parts and has a lever which unfastens both upper and lower hook at the same time and one-half of casing is removed and then the other. In this way there is no danger of knocking down the newly made product.

The molds are made of heavy galvanized steel, reinforced with channel iron in such a way that the molds never get out of shape.

The Latest Miracle

It makes 3,000 to 5,000 Cement Tile per day—each tile perfect in quality, uniform in density from end to end.



The Packer that Packs

uniformly--end to end

When we did the pioneer work introducing Miracle Cement Tile Molds, we set out to give the Cement trade a machine that would do the work as well as it can be done by hand, with a saving of labor cost.

The important problem in the design of a perfect tile machine is in the packing device which does the work of hand tamping when using molds. Miracle machinery is never sold until it has successfully passed the tests of use. Our Baldwin Tile Machine is no experiment. The product could not be made better by the most expert cement worker with hand tamping in molds.

It packs the cement solid; and operates easily and quickly, giving uniform satisfaction. It is practically automatic in operation, the only labor being in the man who removes the finished tile from the machine and puts an empty form back in its place. The price is so low that it comes within the reach of the progressive concrete workers all over America.

Miracle Pressed Stone Co.

Largest Manufacturers of Concrete Machinery in the World

MINNEAPOLIS, MINNESOTA